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STUDIES ON THE THERAPY OF HEMORRHAGIC SHOCK

I. The Effects of Iso-Osmotic and of Concentrated Serum and Plasma in Normal Dogs

H. NECHELES, M.D., Ph.D., S. O. LEVINSON, M.D., MARTHA JANOTA, M.S., R. E. WESTON, M.D., Ph.D., and V. WEISSMAN, Chicago, Illinois

TODAY, the rôle of decreased blood volume in the pathogenesis of shock or peripheral circulatory failure following surgical operations, tissue injury, burns, severe hemorrhage, and other conditions, is universally recognized. Although investigators disagree as to the mode of production of the oligemia, most of them agree that the impairment in the circulation due to the oligemia and to the consequent physiological compensations, in turn, leads to tissue ischemia, anoxia, capillary damage, and further loss of intravascular fluid through the damaged capillaries—the well known vicious cycle which leads to death (2, 17).

Modern therapy of shock has been directed toward interrupting this cycle by the rapid restoration of a normal blood volume. That transfusion of fresh whole blood could effectively restore the blood volume in shock was recognized early, but difficulties in typing, preservation, and storage of adequate amounts of citrated whole blood make this substance of limited application, even in civilian life. Moreover, abundant clinical and experimental evidence has established that, even in shock following severe hemorrhage, the important factor is the reduction in blood volume and not the loss of red cells (12).

During and after the first World War the search for adequate blood substitutes was greatly accelerated and it was conclusively demonstrated that any substance which is to maintain the circulation must restore the effective osmotic pressure of the plasma. That crystalloid solutions of various types and concentrations fail to correct the circulatory deficiency in shock soon became evident; in fact, with the increased permeability of the capillaries in shock these substances promote further loss of plasma proteins. Various colloids of different origin—acacia, pectin, animal proteins, etc.—have been proposed as blood substitutes but have not found wide or continued acceptance due to immediate or delayed toxic effects or to failure to maintain the circulation in shock.

The past few years have seen the simultaneous development by several investigators of a remarkably effective blood substitute—human plasma protein solutions in the form of serum or citrated plasma. When properly prepared,

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these substances are reaction free and non-antigenic and, in their natural state, are within the range of normal colloid osmotic pressure. Such iso-osmotic serum and plasma have been proved effective in the treatment of shock, clinically and experimentally, and have gained widespread use with excellent results.

More recently, with the development of successful methods for the drying of serum and plasma, the use of hypertonic, and particularly four times concentrated, solutions of human plasma protein has been advocated by some for the treatment of shock. Assuming that the increase in osmotic pressure of the blood following injection of these substances would "reverse the mechanism of shock" and lead to the restoration of the blood volume by withdrawing fluid from the tissues, these investigators (3, 5, 18) have advanced the use of hypertonic protein solutions because the smaller volume facilitated storage and transportation, and permitted rapid administration of the solutions with a syringe, thus circumventing the use and transportation of additional equipment.

Other investigators have failed to find any advantage in the use of concentrated plasma protein solutions in shock. Magladery, Solandt, and Best, found iso-osmotic and concentrated protein solutions to be of equivalent value in the treatment of experimental posthemorrhagic shock. Brown and Mollison, in a clinical survey, reported several contra-indications for the use of four times concentrated serum. Mahoney, Kingsley, and Howland reported that concentrated plasma had no prophylactic or therapeutic value in shock produced by intestinal stripping in dogs. Still others (6, 20), in surveying the use of blood substitutes in the treatment of shock, have noted the fallacy of attempting to draw fluids from the tissues of a severely dehydrated patient.

In view of these conflicting reports and in view of the importance of this subject, particularly to the armed forces, a decision as to the relative efficacy of iso-osmotic and concentrated plasma protein solutions is necessary. Under the conditions of modern warfare, dehydration of combatants before or after injury is almost inevitable and it becomes necessary, therefore, to evaluate the relative effects of iso-osmotic and concentrated plasma protein solutions in relation to the state of hydration of the individual.

Properly to compare the therapeutic efficiency of any proposed blood substitutes the following conditions should be fulfilled: (1) Unanesthetised animals and painless procedures should be employed, in order to avoid the influence of the anesthetic and of pain, and to permit an evaluation of the animal's clinical condition in shock and after infusion. (2) A method of producing shock must be employed, which overcomes the variable resistance of individual animals to shock, and which permits some means of relating the quantity of the therapeutic substance required to replace the fluid, cells, and protein lost by the animal. (3) Properly prepared solutions must be used and these solutions must be administered in comparable amounts, at comparable rates, etc. (4) The state and degree of shock at the time of infusion should be carefully considered in judging the results from the therapeutic infusion. (5) Studies of survival time after therapy must be made.

We have endeavored to fulfill these conditions in a comparison of the effects of iso-osmotic and of concentrated plasma protein solutions on posthemorrhagic shock in both normal and dehydrated dogs. Shock was produced by graded bleeding, a procedure which is not unlike the blood loss suffered on the field of battle and which is known to deplete severely the body reserves of fluid (22). A preliminary report of this investigation has been presented (13). This paper is concerned with our findings in normal dogs; the subsequent two papers (11, 23) report the results in dehydrated dogs and the fluid, cell, and protein shifts before and after plasma protein infusions.

EXPERIMENTAL METHODS

Healthy mongrel dogs were deprived of food the day preceding the experiment but were permitted to drink water. In a typical experiment the right carotid and the right femoral arteries were cannulated, and the right and left femoral and the right external jugular veins were exposed under local (pro-

caine or intercaine) anesthesia. Control arterial blood samples were drawn from one cannulated artery for the following determinations, performed in duplicate: hemoglobin, photocolorimetrically; red cell counts; arterial plasma carbon dioxide by the manometric method of Van Slyke and Neil; hematocrits in Wintrobe tubes; plasma proteins by the micro-Kjeldahl method of Ma; using Kingsley's method (10) for albumin separation; and circulating times by the sodium cyanide method (19). All samples were drawn after 3 to 5 cubic centimeters of blood had passed through the cannula into a graduate. Heparin was the anticoagulant.

Carotid arterial blood pressures were recorded on smoked paper with a glass capsule manometer (1). Total available fluid was measured by thiocyanate dilution (7) and plasma volume was measured by the direct dye method (8), the concentration of thiocyanate and of T-1824 in the plasma being determined with the spectrophotolometer.

At the completion of the control plasma volume determination, the dog was bled 20 to 30 per cent of the estimated blood volume in a 10 minute period. Blood volumes were estimated as one-thirteenth of the body weight. All hemorrhages were from the femoral artery. Carotid arterial blood pressures were recorded during all bleedings and if the arterial blood pressure fell below a mean of 50 millimeters mercury, or if the animal's general condition presaged an immediate fatal collapse of the circulation, the bleeding was stopped and the animal was removed from the operating table. One-half hour later, the compensation to the hemorrhage was assumed to be complete, and the animal was bled an additional 10 to 15 per cent of the estimated blood volume in a 10 minute period. If the animal's condition warranted it, a third bleeding of 5 to 10 per cent of the estimated blood volume was performed one-half hour later.

Our previous investigations had revealed that posthemorrhagic or traumatic shock generally is characterized by a mean arterial blood pressure of less than 70 millimeters mercury, a circulating time of more than 20 seconds and an arterial plasma carbon dioxide of less than 26 volumes per cent. In this study, when at least two of these three criteria of shock were fulfilled one-half hour after any bleeding, control blood samples were drawn and the plasma volume and other determinations were repeated.

The small amounts of blood drawn for the posthemorrhage chemical, blood, and plasma volume studies frequently resulted in fatal collapse of the circulation, for animals in shock are very susceptible to additional losses of blood. If the animal survived the second plasma volume determination, a blood sample for carbon dioxide determination was drawn and iso-osmotic or concentrated serum or plasma was rapidly administered into either the right external jugular or the right femoral vein. After the infusion, a control blood sample was drawn when the blood pressure had reached a steady, usually maximal, level and, then, thiocyanate was reinjected. Forty-five minutes later the postinfusion blood, chemical, plasma volume, and hemodynamic studies were repeated. Then, the cannulated vessels were ligated, the wounds cleansed and packed with sulfathiazole, and the animal returned to its cage at the end of the day for survival time studies. The iso-osmotic serum or plasma (4.5 to 6.00 per cent) was administered by gravity at a rate of from 50 to 100 cubic centimeters per minute in a volume equal to the total volume of blood withdrawn from the animal in the samples, washing of cannulas, hemorrhages, etc. The concentrated serum or plasma (15 to 22 per cent) was administered by gravity or with a syringe at a rate of from 40 to 60 cubic centimeters per minute, in a volume equal to approximately one-fourth of the total volume of blood removed. Thus, all of the animals received comparable amounts of protein, the two types of infusions differing only in the total fluid volume administered. To eliminate the influence of anesthetics in the serum or plasma, blood for all plasma protein solutions was drawn from dogs under local (procaine) anesthesia. To reduce the incidence of reactions, which are not uncommon in canine plasma protein solutions, all serum and plasma was processed (9), and sterility tests were performed on the pooled material before Berkefeld filtration. Pyrogen-

free glassware, tubing, etc., were used throughout. The fourfold concentrated, and many of the iso-osmotic, solutions were prepared by redissolving, in sterile, pyrogen-free water, material dried by vacuum desiccation from the frozen state.

EXPERIMENTAL OBSERVATIONS

By graded bleeding all of the symptoms and most of the principal signs of shock can be produced. The typical response of the dog to this procedure has been described in detail in a previous publication (22), but the critical condition of many of the animals at the time the infusions were administered will bear further emphasis. With few exceptions, the small amounts of blood drawn for the posthemorrhage chemical, blood, and plasma volume determinations aggravated greatly the condition of the animal. Generally, this was reflected by corresponding changes in blood pressure, circulating times, and carbon dioxide values but, not infrequently, the blood pressure variations bore slight relation to the actual deterioration of the animal's condition which was more accurately reflected by the level of the arterial plasma carbon dioxide content.

The animals which survived the posthemorrhage plasma volume determinations followed a steady downward clinical course. All untreated control animals died a short time after the last sample was drawn and only a few of the control animals which received infusions of either 0.9 per cent saline or 5 per cent dextrose in lactate-Ringer's solution in amounts greater than the total blood lost gave a favorable response. The degree of circulatory depression before the infusion can be seen from the posthemorrhage values for blood pressure, carbon dixoide, circulating time, plasma volume, and proteins, for all the normal animals.[1] (An analysis of the fluid, cell, and protein shifts in posthemorrhagic shock before and after infusion will be found in the third paper of this series, 23).

Both iso-osmotic and concentrated infusions were administered to individual animals in different degrees of shock as represented by clinical appearance and objective experimental findings. In some dogs respiration had ceased and the cardiac impulse was imperceptible when the infusion was administered whereas, at the other extreme, there were animals in both groups in which the evidence of shock at the time of infusion consisted of weakness, blood pressure at shock levels, increased circulation time, and a moderately depressed carbon dioxide level. The condition of the animal at the time of infusion has an important bearing on its response to treatment (vide infra). A sufficient number of experiments were performed in order to obtain an equal number of animals in comparable degrees of shock in each group.

TREATMENT OF POSTHEMORRHAGIC SHOCK WITH ISO-OSMOTIC SERUM OR PLASMA

The immediate clinical response to infusion of iso-osmotic serum or plasma was striking in all 9 of the normal animals studied. Even a comatose animal in which respiration had ceased and the cardiac impulse was barely perceptible would exhibit striking improvement as soon as the infusion was begun. The heart beat and the blood pressure would rapidly improve to a degree that was almost proportional to the rate at which the solution was administered. Within a few minutes of the start of the infusion there would occur a spontaneous resumption of the respiratory movements and, by the end of the infusion, the animal would generally present an appearance which contrasted greatly with its previously moribund state. Often, the blood pressure would return to normal levels by the end of the infusion and in no case did it take it more than 10 minutes to reach the maximum level after infusion.

All of the animals except one (No. 5) were in good condition when removed from the table following the injection of the thiocyanate after the infusion. All could stand and walk, and most of them were quite active when placed on the floor. This good clinical condition persisted even after additional blood was removed 45 minutes later for the postinfusion chemical, blood, and plasma volume determinations.

The clinical improvement was paralleled by the marked improvement in the laboratory

[1]Listed in Tables I, II, III, and IV to be published in authors' reprints.

findings. In nearly every case, the blood pressure returned practically to the control level before the bleeding. Moreover, these animals, with the exception of the one noted, were well able to tolerate the additional bleeding required for postinfusion determinations so that at the completion of the experiment the blood pressures were maintained. Circulating times in all animals returned to shorter than control values after the infusion, as has been reported previously (19).

The restoration of plasma volume and plasma protein after infusion was satisfactory in every case. After the protein and fluid shifts which follow infusions had occurred and relative stabilization had taken place, the total circulating plasma protein was considerably above prehemorrhage values in every animal, the plasma protein concentration was within normal ranges in every animal, and the plasma volume was significantly greater than the control value in every animal but in No. 8 in which it was equal to the control value. The changes in red cell and total blood volumes were complicated by movements of red cells which apparently can be rapidly shifted into and out of the circulation. The significance of the changes observed will be discussed in the third paper (23).

The arterial plasma carbon dioxide content seemed to be a better index of the degree of shock, response to therapy, and prognosis than were any of the other criteria. This is demonstrated best by comparing the survival time after infusion with the carbon dioxide level at the time of infusion[1]. If an arbitrary level of 15 volumes per cent is selected, it can be seen that all of the animals with pre-infusion carbon dioxide values above this level survived more than 24 hours. On the other hand, only one animal (No. 4) with a carbon dioxide content below this level survived for this length of time, 2 (Nos. 6 and 7) survived 18 and 21 hours, and the rest survived through the experimental day and were found dead in their cages the next morning.

Similarly, the recovery of the arterial plasma carbon dioxide content after infusion gave the best indication of prognosis for survival for, often, although blood pressure and circulating time had returned to normal after infusion, the arterial plasma carbon dioxide content remained at low levels and the animal would be found dead the next morning. The carbon dioxide recovery in all of the animals receiving iso-osmotic serum or plasma was good, when considered in relation to pre-infusion carbon dioxide levels.

[1]See Table I in reprints of this paper.

TREATMENT OF POSTHEMORRHAGIC SHOCK WITH CONCENTRATED SERUM

As others have noted (22), when concentrated or even iso-osmotic plasma was administered rapidly severe tetany or, sometimes, cardiac arrest occurred, evidently due to the lowering of the free calcium ion by the considerable amounts of infused sodium citrate. No such effects were observed when concentrated or iso-osmotic serum was given at comparable rates. For this reason the normal animals now to be discussed were given only concentrated serum.

The response of the 11 normal animals receiving concentrated serum was decidedly poorer than that of the nondehydrated animals which received iso-osmotic plasma protein solutions. Not infrequently, the rapidly administered concentrated solutions seemingly overburdened the circulation for, during and shortly after such infusions, there occurred a transient bradycardia and a drop in the diastolic pressure. One animal (No. 18), which was in an extremely critical condition at the time of infusion, failed to survive this additional insult and died within 5 minutes, after a temporary improvement in its circulation.

Unlike the animals receiving iso-osmotic infusions, the animals receiving the concentrated solutions gave a delayed and often not very marked clinical response to infusion. No improvement in the animal's condition could be observed for some time after the infusion, and often the animal's general appearance was not greatly changed despite a sustained elevation in the blood pressure. Not many of these animals could stand and only a few of them could walk when they were removed from the table after the maximal blood pressure response to the infusion had been achieved.

After a slight elevation due to the volume of the material injected, the rise in the blood pressure was slow so that the maximal blood pressure response was not achieved for from 15 to 30 minutes after the injection of the concentrated serum. Although in 9 animals the blood pressure returned to levels usually considered above the shock level, in only 2 of these (Nos. 12 and 13) did the blood pressure return to within 20 millimeters of the control value before bleeding. Furthermore, none of these animals were able to maintain these blood pressure levels later when blood was drawn for the "postinfusion" blood, chemical, and plasma volume determinations.

This inability to tolerate loss of small amounts of blood was demonstrated, also, by the deterioration in the general condition of most of these animals at the completion of the final plasma volume determination. Even animals which subsequently survived more than 24 hours seemed moribund and comatose when returned to their cages at night, in contrast to the animals which received iso-osmotic solutions, nearly all of which could walk to their cages at the end of the day. Moreover, the fact that 4 of the 10 animals which survived the initial effects of the concentrated infusion died within approximately 2 hours may be related, in part, to increased susceptibility to loss of blood.

The changes in blood pressure and clinical condition were reflected in part by some of the other experimental findings. In all animals but 1 (No. 15) there was an increase in the plasma volume after the injection of the concentrated serum; however, in only 2 animals was the plasma volume elevated to values significantly greater than the control values, in contrast to the animals that had received isotonic serum. Despite some loss of intravascular protein following infusion, both the circulating protein and the plasma protein concentration were well above the control level in most cases (23).

As in the group receiving iso-osmotic infusions, the arterial plasma carbon dioxide level gave the best index of the degree of shock before infusion, the response to therapy, and the prognosis. Four of the 5 animals with arterial plasma carbon dioxide contents above 15 volumes per cent at the time of infusion survived more than 24 hours, and 1 20½ hours; however, in contrast to the animals which received iso-osmotic serum or plasma only 1 animal with a carbon dioxide below this level survived much more than 2 hours. The recovery of the arterial plasma carbon dioxide content after infusion was good in the 6 animals which survived more than 2 hours, but was poor in 4 of the 5 which died within 2 hours of the injection of the concentrated material.

SUMMARY AND CONCLUSIONS

These results demonstrate that iso-osmotic plasma protein solutions are more effective in the treatment of posthemorrhagic shock in normal dogs than are concentrated solutions. The relative clinical improvement, restoration of blood pressure and plasma volume, ability to tolerate further blood loss, and survival times strikingly demonstrate the superiority of iso-osmotic over concentrated material.

The assumption underlying the use of four times concentrated plasma protein solutions in the treatment of shock has been that these solutions can increase the plasma volume as efficiently as larger amounts of iso-osmotic plasma or serum by elevating the intravascular osmotic pressure and thereby withdrawing fluid from the extravascular tissue spaces. However, when, as in these experiments, there has been considerable external hemorrhage, the extravascular reserves are greatly depleted as fluid shifts into the circulation in the early physiological compensations for the blood lost from the body. Consequently, in many of our normally hydrated animals which received the four times concentrated material, despite the fact that after the infusion the blood pressure failed to return to prehemorrhage levels and the osmotic pressure (total plasma protein concentration) was above normal levels, the plasma volume recovery was poor in comparison with that of the animals which received comparable amounts of protein but additional fluid in the iso-osmotic material.

Moreover, the possibility has been neglected that the gain in circulating intravascular fluid might be achieved at the expense of the intra-

cellular as well as the extracellular fluid, with added damage to tissues already injured by prolonged oligemia and anoxia. That the latter may be true is indicated by the poor survival times of the animals with arterial plasma carbon dioxide levels below 15 volumes per cent, at the time concentrated serum was injected. Despite the increase in plasma volume, these animals exhibited slight clinical improvement and poor survival times when compared with those which received iso-osmotic solutions. Since the main premise in the treatment of shock is the restoration of circulating plasma volume, the administration of concentrated solutions in shock from repeated or prolonged hemorrhage does not seem to be a physiologic procedure.

These results demonstrate that in the treatment of shock produced in animals by graded bleeding, a procedure which severely depletes the body reserves of fluid, concentrated plasma protein solutions are inferior to iso-osmotic solutions. It is to be expected, therefore, that the treatment of hemorrhagic shock with such concentrated solutions would be even less effective in animals which have been dehydrated by withholding of water before the experimental hemorrhages (11).

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A NEW OPERATIVE APPROACH TO THE KNEE JOINT

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IN the ordinary type of incision used in exploration of the knee joint, be it of the lateral, medial, or combined type, visibility is usually inadequate and only accomplished by forceful retraction of the knee joint tissues. The incision here described has afforded excellent visibility of all knee joint structures, and we believe it to be the only surgical approach permitting satisfactory open reduction of intra-articular fractures of the knee joint. In addition to the virtue of simplicity of approach and repair, it reduces to a minimum the necessity of retraction.

OPERATIVE TECHNIQUE

The usual type of paramesian skin incision is used, beginning at the lower end of the quadriceps muscle near the beginning of the tendinous portion, swinging either medially or laterally along the edge of the patella and the patellar tendon. The skin is then dissected from the patella. The quadriceps tendon is split down the middle, beginning at the upper end where the tendinous portion joins the muscle. At a point about one-quarter to one-half inch above the upper portion of the bony patella, the incision is swung both medially and laterally, continuing about the same distance from the patella down along the patellar tendon. One usually encounters a small bleeder in the fat pad at this point which is readily controlled by ligature. The patella and patellar tendon drop downward, thus affording a complete exposure of the joint. When the sides of the patellar tendon are retracted medially and laterally, respectively, the entire lower end of the femur and quadriceps pouch are readily exposed. By acute flexion of the knee, complete visualization and palpation are possible.

In closure, the knee is extended and the patella pulled upward into its normal position. This permits the line of incision to come together without the slightest tension. One or two anchor sutures of fairly heavy Deknatel silk are taken at the point where the patella joins the two halves of the quadriceps tendon. The quadriceps tendon and the edges of the patellar tendon are sutured together with heavy chromic catgut, following which the line of suture is tested by acute flexion of the knee. The fascia and skin are closed in the usual fashion without drainage.

Postoperative care. A ham splint is ordinarily applied at the time of operation, and quadriceps setting exercises are carried out hourly as soon as the patient recovers from anesthesia. On the 7th or 8th postoperative day, the ham splint is removed, the wound is dressed, an ace bandage is applied, and active functional use without weight bearing is allowed. Quadriceps setting exercises are continued throughout the convalescent period. On the 10th to 14th day, weight bearing is allowed with the use of crutches. In from 3 to 4 weeks the patient should be ambulatory without the use of a cane or crutches. Sutures are usually removed at the end of 2 weeks, and the incision is strapped with flamed adhesive.

Discussion of procedure. This operative approach to the knee joint obviously affords numerous advantages over the ordinary type of incision. It enables one to obtain complete visualization of the knee joint structures with a minimum of trauma and a maximum of exposure. Thus, in the case of transverse or T fractures near or into the joint, accurate approximation of the joint surfaces may be obtained. With this exposure, drilling and bolting of the fragments are accomplished with relative ease. In bolting the fragments it is wise to place the bolts posterior to the quadriceps pouch. This is readily accomplished by opening the quadriceps pouch posteriorly, drilling the necessary holes, bolting the fragments and then suturing the posterior layer so that the bolts are actually posterior to the knee joint proper. This complete exposure enables one to visualize all abnormalities of the knee joint including internal derangements

Fig. 1. The skin incision is shown in the insert. Large drawing shows incision carried through quadriceps tendon along each side of the patella and the patellar tendon. Following this the knee is flexed (see Fig. 2).

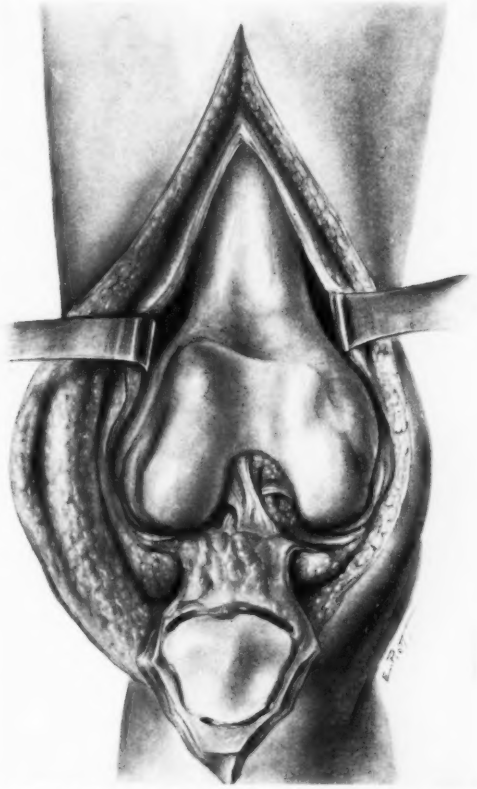

Fig. 2. The extent of exposure of knee joint and lower end of femur when knee is flexed and patella is allowed to drop downward. Note the extent of visualization of lower end of femur, cruciate ligaments, and cartilages.

such as injuries to the cartilages, torn cruciate ligaments, joint mice, arthritis, and other pathological changes such as osteochondritis dissecans. We particularly wish to emphasize that this incision practically eliminates the need for retraction and thereby minimizes trauma to the knee joint structures. Convalescence in the operative cases has been unusually rapid with relatively little discomfort.

CASE REPORTS

A summary of four cases follows:

CASE 1. M.C., female, aged 70 years. Patient stated that while outdoors on the afternoon of February 6, 1942, she slipped on the wet pavement and fell forward to the ground onto her hands and knees. In trying to get up from the sidewalk, she fell again, this time falling sharply onto her right knee, and she was unable to get up. She was assisted to her feet but her right knee was extremely painful and she was unable to move it. She was then assisted home and was brought to the hospital by the house ambulance. Patient was admitted to the ward after having been seen in the plaster room where a long leg cast was applied with no attempt at reduction. Closed reduction was attempted on February 9, 1942, and x-ray films showed still some displacement of fragments. On February 19, 1942, open reduction with fixation of the lateral condyle by means of two metal bolts and nuts was done. Patient was returned to the ward and the leg was suspended in balanced overhead suspension. X-ray examination on February 25, 1942, showed good position. On March 4, 1942, all sutures were taken out and the wound was clean and healed. On March 9, 1942, balanced suspension was removed and on March 13, 1942, patient was up and about on crutches with no

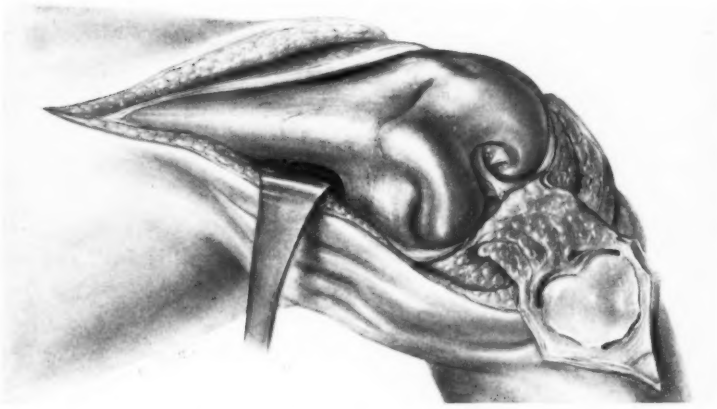

Fig. 3. A semilateral view of the joint. The simplicity of bolting or plating fractures of the lower end of the femur is shown. With this incision very little retraction is required.

weight bearing. Patient was discharged on March 14, 1942, on crutches with no weight bearing.

Operative note. Under general anesthesia, with a tourniquet about the right upper thigh, the leg was prepared with 2 per cent iodine and draped with the extremity free. A 7-inch incision was made on the anterior aspect of the lower femur and knee joint in the midline. After the skin and subcutaneous tissues had been retracted, a Y-shaped incision with the stem pointing proximally was made in the quadriceps tendon. This allowed the patella to be turned down distally. The quadriceps muscle was then stripped up from the lateral condyle for about one-half its width. The fragment was opposed to the main shaft fragment and two bolts were inserted through drill holes and nuts applied on the medial aspect. The articular cartilage in the joint was not exactly anatomical but the position was good. The wound was then sprinkled with about 3 grams of sulfanilamide crystals and the Y incision in the quadriceps tendon closed with No. 1 chromic catgut continuous sutures. Several interrupted sutures were taken also. The subcutaneous tissue was closed with fine plain catgut and the skin closed with a running black silk suture. Postoperative condition was excellent. Patient returned to the ward and put in a Thomas splint with Pearson attachment.

On February 18, 1943, patient stated that she was able to carry on all her normal activities and had no symptoms referable to the right knee. She did not limp. Examination at this time showed that the incision was well healed. She had complete extension. Both knees appeared symmetrical. She had flexion to about 40 degrees beyond the right angle. No increased anteroposterior mobility and she had no appreciable increase in lateral mobility. There was a slight amount of thickening. The midpatella on the right was 14¾ inches; upper border of patella 14½ inches, and lower border 13 inches; midpatella on the left was 14 inches; upper border of patella 14 inches and lower border 12½ inches. There was some creaking in both knee joints, not any more appreciable on the right than on the left.

Case 2. F.W., male, aged 38 years. Patient was admitted to Beverly Hospital in March, 1943, with chief complaint of a "bad knee" of 1 year's duration. He has always been in good health except for asymptomatic lues discovered by positive serology on routine blood examination 1 year ago. At about this same time, patient first began to complain of weakness and pain in the right knee, most marked at lateral aspect of the knee at the edge of the patella. The knee would occasionally give way during ordinary walking but patient has never fallen. There has been no swelling or marked tenderness at any time. Arch supports gave some relief, although pain and weakness persisted steadily up to present time. X-ray films showed question of fracture or bipartite patella.

Examination showed no relaxation of the quadriceps tendon or increased lateral mobility of the joint itself. Full flexion was possible but it was limited to within 5 degrees of full extension and caused some discomfort under the patella itself. There was no capsular thickening and no especial tenderness over either semilunar area. There was a very slight amount of crepitus in the joint on motion. Inasmuch as this patient had not responded to any of the conservative measures, it was thought advisable to explore this knee.

On March 19, 1943, an exploration of the right knee with the incision described showed a fibrosed fat pad which was removed in part. Nothing abnormal could be found in the joint. This patient made an uneventful recovery and weight bearing was begun 2 weeks following operation.

CASE 3. R.A.C., male, aged 18 years. In October, 1941, patient was struck in the left knee while playing football. The knee swelled a good deal. It would snap out of joint and then back again. In December, 1941, he bent down to pick up some object and could not straighten out the knee. He was then taken to the Boston City Hospital. A cast was applied and he went home the same day. Cast was on 3 weeks. Went to Boston City Hospital clinic several times. Three weeks ago was seen at the Boston Dispensary.

On February 27, 1943, operation as described was done. A very large cystic semilunar cartilage about the size of a small English walnut was removed. It was attached only by the posterior horn. It would have been impossible to have delivered this and taken it out in entirety through the ordinary parapatellar incision. As usual, a posterior ham splint was applied. He had a perfectly uneventful convalescence. Wound was clean and stitches out.

On March 8, 1943, this boy was taken with acute pain in his side and on investigation vomited some blood. He unquestionably had a pulmonary infarct. This all cleared up by March 22 and the boy was up and around on crutches. Convalescence was obviously prolonged through the complication of the infarct. He had been carrying on his splinting of the quadriceps group of muscles. On this date, the knee went to full extension and to right angles and apparently there was no weakening of the quadriceps group. On April 1 the boy was around without crutches. He had practically no limp. Knee went to beyond a right angle and to full extension. He had less than three-quarters of an inch of atrophy through the thigh with good quadriceps power. He had been working actively on his feet 2 days that week.

CASE 4. F.B. male, aged 42 years. Patient stated that on January 15, 1943, about 7 a.m. he slipped on the ice while at work and fell, twisting his left knee. He stated that the knee had been splinted and bandaged until about February 11. He said that he had had previous fractures of both bones of the right lower leg.

Examination revealed mild, nontender swelling in the infrapatellar region. There was a very mild defect in complete extension and there was a mild restriction in flexion accompanied by complaint of pain. There was no abnormal mobility present and there was no pain complained of on testing for this. The musculature of both legs, upper and lower, was very light but there was no apparent atrophy of the left leg.

On examination on March 10, 1943, he had a very slight amount of increased joint fluid which was readily demonstrable in a standing position. He had fairly acute tenderness along the internal semilunar cartilage, particularly near the internal lateral ligament. Extension lacked about 5 degrees and any attempt to force extension produced discomfort referred to the medial side and back of his joint. Flexion lacked possibly 5 degrees and external rotation produced discomfort over the medial cartilage region. Internal rotation produced only mild discomfort. There was no increase in anteroposterior or lateral mobility in either flexed or extended position.

Operation was done on April 8, 1943. Under spinal anesthesia, a tourniquet was applied to the left thigh. The field was prepared and draped in the usual fashion. A routine skin incision was made and the skin isolated. A quadriceps splitting incision was carried along both sides of the patella. The knee was flexed and the medial cartilage found to be loose in its posterior third. This was excised. The external cartilage appeared to be normal in position and relationships. Routine inspection of the joint revealed no other pathology. The wound was closed in the usual fashion with three Deknatel silk sutures. The balance of the incision was closed with chromic No. 1 catgut, silk to the skin. Sterile dressings and ham splint were applied. Postoperative course to date has been uneventful with remarkable freedom from postoperative pain.

SUMMARY

A new operative approach to the knee joint is herein described which we feel has numerous advantages as compared with the various standard incisions now employed.

1. It affords maximum exposure with a minimum of retraction.

2. Because of the ease of retraction, there is relatively little trauma to knee joint structures.

3. The incision is relatively avascular (the only vessel encountered being in the fat pad near its lower portion).

4. It is the only incision with which we are familiar which enables one to secure a surgical approach and adequate treatment of fractures in and about the knee joint.

5. The exposure is ideal for synovectomy.

6. It is an excellent exposure for arthrodesis.

7. In our experience it is the only type of operative approach and repair which will permit acute flexion of the knee (prior to skin closure) without separation of the line of suture.

8. We wish to emphasize particularly that there has been no demonstrable weakness or impairment in function of the quadriceps following operative repair although the ages in the reported cases ranged from 18 to 70 years.

A STUDY OF THE SMALLER BLOOD VESSELS IN BURNED DOGS AND CATS

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ANIMALS which have been seriously burned exhibit many of the signs which accompany shock produced by limb tourniquets and by allowing plasma to escape from peritoneal surfaces. Page and Abell found (5) that arteriolar vasoconstriction was one of the most characteristic hemodynamic changes accompanying tourniquet shock and that this was present both in the mesenteric vessels of cats and the peripheral vessels of the rabbit's ear. Further, it has been shown by Page (3) that the plasma of dogs in shock from tourniquets, hemorrhage, and from burns assumes vasoconstrictor properties when studied in the perfused rabbit's ear preparation. It naturally followed that vasoconstriction might be found in burned animals as well. If this were so, it would present a more unified picture of a part of the mechanism of shock produced by, or associated with, these diverse methods.

To our surprise we have not found in the literature any study, which is more than very casual concerning the state of the blood vessels after burns. Since the method of Zintel for observation of the mesenteric vessels as developed in Clark's laboratory is so well adapted to studies of this kind, we have used it and the results are the subject of this paper.

METHODS

The methods employed have been essentially the same as those we used for the study of shock (5). The dimensions of the chambers for the cats were the same as given by Zintel. A chamber resembling the Zintel chamber, but larger, was designed for dogs. In it, the channel for the intestine was 20 millimeters in diameter, which was found to be adequate for the largest dogs used in these experiments (14 kilograms).

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In all of the cats the body wall at the site of the incision was sewn tightly into the flanges of the chamber. This was done also in 5 of the dogs. In the remainder the chamber was stitched loosely to the skin, in order to avoid movements due to respiration. In previous experiments the chambers were inserted into a midline incision. This was done in 4 of the cats and 5 of the dogs in these experiments. In the remaining animals a right rectus incision in the right lower quadrant was used, which was found to be more satisfactory when the chambers were held horizontally, especially in the case of the dogs.

Most of our observations were made with the chamber held rigidly in a horizontal position. The vessels were studied at magnifications of from 21 to 400 diameters.

The portions of the gut used were the jejunum and ileum.

Arterial pressure was measured by direct carotid arterial cannulation. The anesthetic was pentobarbital (30 mgm. per kgm. of body weight). The clipped legs of the animal were burned by immersing them in boiling water for about 2 minutes. In 2 animals the burn was inflicted by live steam from a funnel.

The larger arteries studied had control diameters of from 0.2 to 1.5 millimeters and the smaller arteries from 0.024 to 0.096 millimeter; the larger veins had diameters of from 0.3 to 2.1 millimeters and the smaller ones from 0.03 to 0.144 millimeter.

OBSERVATIONS

Control. In 6 dogs the vessels were observed for periods of 6 to 11 hours to ascertain what changes if any occurred spontaneously. The variations that can be expected are: (1) larger arteries—no narrowing at all, or in some cases narrowing to about 0.8 the control diameters; (2) smaller arteries—no change at all or in some instances narrowing to about 0.9 of the control diameters; (3) larger veins—no change

at all or in some cases narrowing to about 0.8 of the control diameters; (4) smaller veins—in some cases slight widening or narrowing. The flow of blood changes insignificantly. Similar results were secured with 3 cats observed for periods of 3 hours before burning. The capillaries were all open and none were constricted, as seen not only in the mesentery, but also in the wall of the gut itself.

Experimental. Fifteen dogs and 5 cats were used for the experiment. Within 10 to 90 minutes the larger arteries began to constrict. There was progressive constriction reaching a maximum in about 2 hours. The degree of constriction was usually to 0.3 to 0.6 the control diameters. Such constriction is shown in Figures 1 to 4.

The smaller arteries also constricted in about the same manner, as shown in Figures 5 to 8. The degree was usually to 0.2 to 0.6 the control diameters (Tables I and II). Such constriction began well before fall in systemic pressure. In some cases arterioles having control diameters of 24 microns were seen to constrict to the point of cutting off the blood flow (see A3 and A4 of Table I). The same type of constriction was observed in the arteries of the intestine. A short time before death the arteries not infrequently relaxed somewhat, but never beyond the control diameters, and usually not that much (cf. A2 and A3 of Table II).

The smaller veins did not constrict appreciably; possibly in the cats there was a slight narrowing, but in the dogs there was frequently slight dilatation toward the end of the experiments.

The larger veins usually became markedly narrowed. In some of them a series of constrictions produced sausage-shaped segments which changed from time to time. As confirmation of the vasoconstriction it was observed that the mesentery became distinctly blanched and the gut bluish. The tongue of the animal simultaneously assumed the same color.

The rate of blood flow always decreased, beginning in some experiments within 10 minutes and in others not for an hour or two. The flow diminished progressively until there was frequently little or no movement of the corpuscles in the smaller arteries and veins or in the capillaries. Stasis was not uncommon in many of the capillaries and venules half an hour to an hour before death.

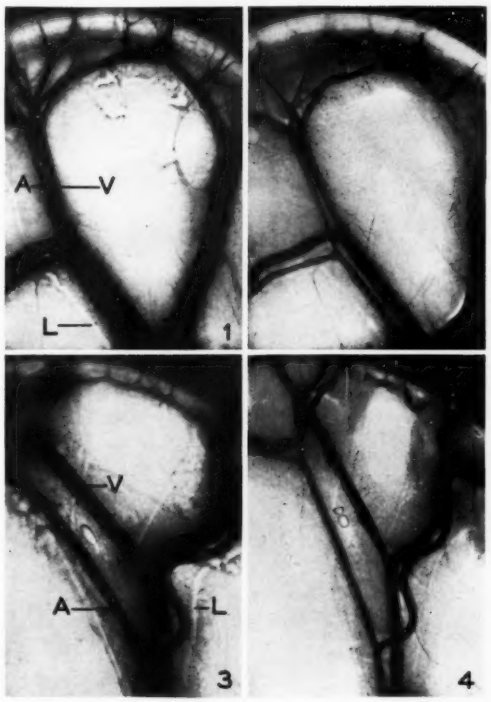

Fig. 1. Control. Photograph showing the appearance of the larger vessels of the mesentery of cat 3, before burning. *A*, artery; *V*, vein; *L*, lymphatic. ×2.

Fig. 2. The same vessels 1 hour after the legs were placed in boiling water for 2 minutes. Note vascular constriction. Observations at this time showed much reduced blood flow. ×2.

Fig. 3. Control. Photograph showing the appearance of the larger vessels of the mesentery of cat 5, before burning. *A*, artery; *V*, vein; *L*, lymphatic. × 2.28.

Fig. 4. The same vessels 4¾ hours after the right hind and front legs and side were burned with live steam. Note vascular constriction. The blood flow at this time was much reduced. ×2.28.

The capillaries, especially in the cat's mesentery, were very clearly seen. The endothelial walls were visible and the endothelial nuclei as well. We were unable to see any significant change in the diameter of the capillaries after burning in the 5 cats examined. Especially there was no opening up of constricted capillaries since control observations showed no constricted capillaries.

TABLE I.—THE EFFECT OF STEAM BURN OF THE LEGS AND BODY UPON THE DIAMETERS OF THE SMALLER AND LARGER ARTERIES AND VEINS OF THE MESENTERY OF THE DOG

Smaller vessels—diameters in millimeters

Time	A_1	V_1	A_2	V_2	A_3	V_3	A_4	V_4	A-V-A	B.P. mm. Hg.
1:25 p.m.	0.072	0.120	0.072	0.108	0.024	0.030	0.024	0.038	0.024	140
2:45—3:21	Steam burn, small areas at a time.									
3:10	0.072	0.120	0.072	0.108	0.024	0.030	0.024	0.038	0.000	144
3:37	0.072	0.120	0.072	0.108	0.024	0.020	0.000	0.038	0.000	142
4:05	0.048	0.120	0.048	0.108	0.009	0.030	0.000	0.042	0.000	140
4:50	0.048	0.120	0.048	0.108	0.000	0.030	0.000	0.042	0.000	124
6:30	0.030	0.120	0.030	0.108	0.000	0.030	0.000	0.042	0.000	124
9:25	0.024	0.120	0.018	0.108	0.000	0.030	0.000	0.042	0.009	102

Larger vessels—diameters in millimeters

	A_5	A_6	V_6
1:00 p.m.	0.90	0.90	2.10
2-45—3:21	Steam burn.		
5:55	0.36	0.36	0.90

A_1, A_2, etc. arteries; V_1, V_2 etc. veins; A-V-A, arteriovenous anastomoses. The dog was sacrificed at 10:00 P.M. Autopsy showed extensive hemorrhages in the endocardium of the left ventricle, the valves of the left ventricle; massive hemorrhages in the spleen; hemorrhages and extensive edema in the steamed areas.

TABLE II.—THE EFFECTS OF BURNS OF THE LEGS UPON THE DIAMETERS OF THE LARGER AND SMALLER ARTERIES AND VEINS OF THE CAT'S MESENTERY

Larger vessels—diameters in millimeters

Time	A_1	V_1	A_2	V_2	A_3	V_3	B. P. mm. Hg.
1:35 p.m.	0.21	0.42	0.30	0.30	0.60	0.60	108
2:40—2:47	legs burned						
2:51	0.12	0.24	0.15	0.21	0.36	0.45	114
3:15	0.12	0.24	0.15	0.15	0.36	0.45	96
4:00	0.09	0.24	0.15	0.18	0.36	0.45	108
5:10	0.09	0.21	0.21	0.21	0.45	0.45	42

Smaller vessels—diameters in millimeters

Time	A_4	V_4	A_5	V_5	A_6	V_6
1:50 p.m.	0.024	0.050	0.038	0.048	0.036	0.048
2:40—2:47	legs burned					
4:30	0.012	0.050	0.012	0.048	0.030	0.048
4:58	0.012	0.048	0.012	0.048	0.024	0.048

The legs were burned by placing in boiling water for 2 minutes. The cat died at 5:18 p.m. Autopsy showed small hemorrhages in the mesentery; small hemorrhages in the endocardium of the left ventricle and one in the right ventricle; hemorrhages of the lungs.

In 3 dogs and 2 cats the lymphatics were measured: in one of the dogs narrowing occurred to 0.7 of the control diameter after burning, in the second to 0.5, but in the third no change was observed. In one dog the rate of flow in the lymphatics was measured by the movement of white corpuscles. Before the burn it was 57 microns per second. Two and one-half hours later it had increased to 88 microns per second. Fifteen minutes before death it had become much faster but the rate was not measured. In the cats the lymphatics

narrowed to about 0.4 to 0.7 their control diameters (cf. Figs. 1 to 4).

The blood plasma developed vasoconstrictor properties as measured in the perfused rabbit's ear preparation of Page (4) in all of the animals so tested (3 dogs).

Arteriovenous anastomoses were observed to constrict shortly after burning and not infrequently before the parent vessels. The effect was to cut off the shunt, so decreasing the venous return to that extent.

The area burned was greater in the animals exposed to steam than in the others and the amount of edema was greater. In these animals, in addition to the things described, the erythrocytes in the smaller venules became packed tightly against each other and against the vessel walls (cf. Fig. 9). The blood moved forward slowly and with difficulty at this time; in many venules it stopped abruptly during expiration and moved forward only slowly during inspiration, as though its viscosity were abnormally great. Little or no plasma could be seen between the erythrocytes themselves or between them and the venule walls, a striking contrast with the control condition. When movement was present the appearance was that of a material of high viscosity being pushed along with difficulty.

The erythrocytes not only became abnormally crowded in the venules in the animals burned with steam, but they also stuck to each other. In consequence the blood moved forward as a solid column of cells, or when this became broken, as clumps of erythrocytes which were pushed through the vessels with difficulty and not infrequently got stuck.

Normally, a leucocyte stuck to the wall of a venule has no pronounced effect upon the blood flow, since the erythrocytes in the plasma readily slip around it and do not adhere to each other. But in these instances, when the erythrocytes were crowded together and stuck to each other, and the venules tightly filled with them, even a single leucocyte stuck to the wall impeded and frequently stopped the flow.

Hematocrit determinations showed marked hemoconcentration after the animals were burned with steam. For example, in one dog the percentage of erythrocytes in the blood increased from a control of 42 to 65 within half an hour after onset of the burn.

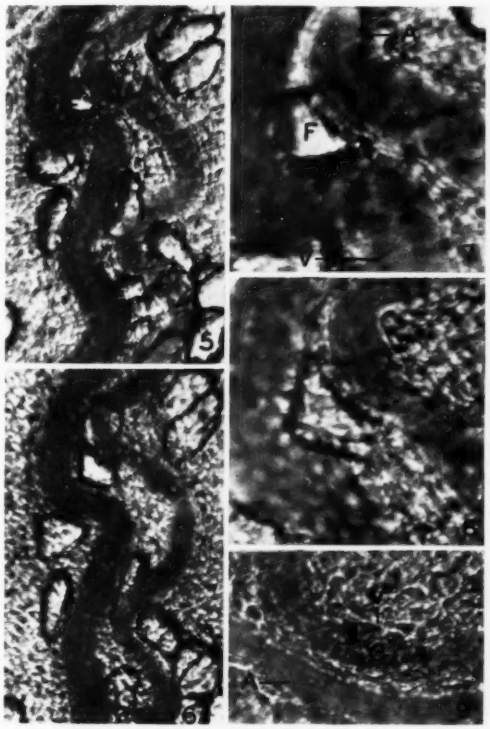

Fig. 5. Control. Photomicrograph of two of the smaller vessels of the mesentery of cat 5, before burning. The actual diameter of this arteriole was 40 microns. *A*, arteriole; *V*, venule; *F*, fat cell. ×120.

Fig. 6. The same vessels 2 hours after cat was burned with steam. Note arteriolar constriction; blood flow much reduced.

Fig. 7. Control. Photomicrograph of a portion of the same arteriole and venule as in Figure 5, but at higher magnification. The letters *A*, *F* and *V* are in the same relative positions as in Figure 5. ×240.

Fig. 8. The same vessels as in Figure 7, 2 hours after cat was burned. Arteriole is constricted, blood flow reduced.

Fig. 9. Photomicrograph of an arteriole, *A*, and venule, *V*, in another portion of the mesentery of cat 5, 2½ hours after the cat was burned. The venule contains blood cells (*C*) packed tightly together and against the sides of the vessel, so that the walls are not clearly visible. The line from *V* ends on one wall of the venule. There is no flow of blood in this vessel, as shown by the absence of a blur such as seen in the arteriole. This lack of flow was caused in part by the marked hemoconcentration. ×240.

EVALUATION OF STUDY

The response of the vascular system to burns seems to be almost identical with that ob-

served by us in shock produced by tourniquets obstructing the flow of blood to the limbs. The irregular constriction of the veins was not seen in the latter, nor was stasis of blood in the mesentery or concentration of corpuscles within the vessels. In this latter connection it should be noted that hemoconcentration was marked in the present experiments, whereas in the previous experiments it was only moderate. Arterial constriction in the present experiments was also somewhat greater, so that the blood flow was consequently more reduced. The previous experiments dealt with cats. Recently we have put into shock by incomplete occlusion of the limb circulation 4 dogs containing intestinal-mesenteric chambers, and in these cases not only was marked reduction of flow observed in the mesentery, as in the cats, but also stasis in some of the capillaries and venules shortly before death.

Just as in shock produced by tourniquets, vasoconstriction caused by burns begins well before systemic arterial pressure starts to fall. The result is progressively diminished flow of blood to the periphery and reduced return to the right heart. Aiding in this reduction is the cutting off of the arteriovenous anastomoses, and, in cases of marked hemoconcentration, increased viscosity of the blood. Because of their high reactivity (Clark and Clark) it is to be expected that arteriovenous anastomoses should close rather abruptly following burns.

It cannot be said with certainty that the changes observed in the mesenteric vessels will be the same as those in peripheral vessels such as those of the ear. Previous experience, however, indicates that arterial constriction with reduced flow in the one will be reflected in the other. The bluish-red cyanotic hue which develops in the intestine as the result of vasoconstriction and hemoconcentration is paralleled by similar change in color of the tongue. We believe that cyanosis of the intestine can be predicted from the color of the tongue in dogs.

The sticking of erythrocytes to each other, such as described in the present experiment, was recently reported in dogs during traumatic shock by Knisely. Since it has been shown (Page, 3) that the plasma of burned animals acquires vasoconstrictor properties it seems reasonable to relate this to the vasoconstriction we have observed in these experiments. However, no attempt was made in the present experiments to separate the effect of such humoral factors from possible nervous ones, nor can we be sure how much of the narrowing of the vessels is passive due to decreased blood volume.

It appears that release of a substance which causes vasoconstriction, without augmenting the force and output of the heart, must inevitably lead to diminished return of blood to the heart and failure of the peripheral circulation. The opposite of this hemodynamic picture was recently encountered in one of our patients (Page, Kohlstaedt, and Taylor, 6). The man had taken arsenic for suicidal purposes. Despite the fact that arterial pressure fell to about 38 millimeters mercury mean pressure in the recumbent position, he felt well and was able to rise and walk without difficulty. Flow to the peripheral tissue was not appreciably reduced. The explanation for his lack of symptoms appears to have been that the output of the heart was nearly tripled and peripheral resistance fell to a very low value; a picture quite the opposite of shock.

SUMMARY

1. Burns produced in dogs and cats by hot water or steam are associated with the occurrence of severe vasoconstriction in the larger and smaller arteries and the larger veins. In dogs the smaller veins either remain unchanged or dilate slightly; in cats they do not change appreciably or may become slightly narrowed. Irregular constriction in the larger veins occurs in roughly a fourth of the animals. No change in diameter was seen in the capillaries.

2. Arteriovenous anastomoses constrict after burning, so aiding in reducing the return flow to the right heart.

3. Vasoconstriction occurs before fall in systemic arterial pressure is observed.

4. The rate of flow of blood decreases sharply after burning and continues to diminish with the passage of time. Frequently stasis develops in many of the capillaries and venules half an hour to an hour before death.

5. When hemoconcentration was very great the erythrocytes in the smaller venules were seen to be tightly packed against each other and against the vessel walls. This increased the resistance to movement of the blood.

6. In most instances the mesenteric lymphatics became narrowed after burning the limbs. In one experiment, the rate of flow of lymph was observed to be greatly increased.

CONCLUSIONS

Burns in dogs and cats produce vasoconstriction of the larger and smaller arteries and larger veins, which combined with constriction of arteriovenous anastomoses and packing of erythrocytes, results in reduced blood flow to the tissues and inadequate return of blood to the heart. It is suggested that this vasoconstriction might be due, at least in part, to a vasoconstrictor substance appearing in the plasma as a result of the burn.

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ATRAUMATIC AMPUTATION THROUGH THE LOWER THIGH

Experiences with Its Use in Peripheral Vascular Disease

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ABOUT 12 years ago, re-awakened to the shocking mortality of amputation for chronic occlusive peripheral vascular disease, and aware of the lack of satisfactory criteria for the conduct of the serious complication of such affections, one of us began to give special attention to disorders of the peripheral vessels and established the Clinic of Sympathetic and Vascular Surgery for purposes of study. It is the general rule that, as soon as cases of peripheral vascular disease in any institution are placed under the care of men especially interested and trained in their conduct, the results at once begin to improve.

In the majority of cases in which removal of a portion of the lower limb was necessary, amputation was done above the knee. The operation was performed by the usual "tendoplastic" technique until 1935 when Callander (1) reported his technique for supracondylar thigh amputation which cut through no muscle bellies. This technique was considered especially suitable for cases of peripheral vascular disease for the following reasons: (1) no tourniquet is used; (2) the natural barrier to infection formed by the fascia of the popliteal space is preserved; (3) no muscle bellies are cut; (4) long, viable skin flaps may be fashioned from the upper leg; (5) the closure includes only skin and subcutaneous tissue, is affected without tension, and allows ample room for drainage; (6) the stump is long, mobile, and end-bearing; (7) operative shock is minimal; and (8) the patient may be allowed in a chair on the first day after operation.

The operation was so satisfactory that it was adopted as the routine lower thigh amputation in the clinic. After performing 15 amputations according to the original technique, one of us (F.L.P.) modified the procedure in an attempt to improve the results. The reasons for and the nature of the modification have been set forth elsewhere (12). The present report deals with our results in 36 amputations for peripheral vascular disease performed by the basic technique which cuts no muscle bellies—15 cases by the original Callander operation and 21 by the Pearl modification. Whereas our series is small, it was our opinion that our experiences with a comparatively new amputation were worth reporting.

From the Clinic of Sympathetic and Vascular Surgery, Mount Zion Hospital.

GENERAL CONSIDERATIONS

It is not the authors' intention to enter deeply the controversies regarding indications for treatment of vascular disease and its complications; sites and times for amputation; or other subjects on which well informed surgeons have honest differences of opinion. Certain points, however, should be emphasized.

The proper surgical treatment of infection, ulceration, or localized gangrene in any extremity which is the site of peripheral arterial disease depends to a great extent on the circulatory balance of the extremity. If the arterial circulation is competent, local operation may be done under certain circumstances; if incompetent, such surgery is always contraindicated. It is a matter of nice surgical judgment based upon special training and experience in estimating the circulatory balance, as to when local surgery is allowable. The cold, pulseless foot which blanches on elevation and becomes erythromelic on dependency will not stand the additional insult of surgical trauma. Yet the absence of pulses alone does not contraindicate local operation if the foot is warm and shows no postural color changes. Surgery performed on feet with

incompetent circulation is not only meddlesome; the delay entailed and the lowering of local resistance invites the onset of spreading infection which may overwhelm the defenses of the patient's blood stream before even high amputation can come to his rescue. It is well recognized that uncontrolled diabetes greatly accentuates the liability of spreading infection. Its presence must always be ascertained. Diabetes properly controlled before, during, and after surgery adds no great danger to the operative procedure; yet other things being equal, the controlled diabetic surely has not the resistance to surgical trauma that one finds in the nondiabetic.

INCOMPETENT CIRCULATION WITHOUT INFECTION

The ulcerated or gangrenous extremity, which after careful examination is judged to have an incompetent arterial circulation, is treated conservatively for from 3 to 4 weeks in the hospital as long as there are no signs of spreading infection. If there is no satisfactory improvement, amputation should then be considered. It is useless and dangerous, as well as economically wasteful, to prolong conservative treatment past the time when improvement is obviously not going to take place. The lesion may be relatively free of infection so that amputation may be delayed with little additional risk; but once cellulitis or lymphangitis has occurred, the patient should be urged to accept the inevitable. The surgeon must squarely face the amputation issue and communicate his mature unequivocal decision to the patient, despite the natural abhorrence which we all feel toward mutilation. Some surgeons share that "I would rather be dead" attitude expressed by patients who are face to face with the amputation dilemma; yet the attendant's duty to prolong life is clear-cut, even when an extremity must be sacrificed. Often he must disregard the wishes of the family for nonintervention when the patient's own desire is to submit to surgery. Many feel that the amputee is usually psychologically crushed by his misfortune—doomed to a life of unhappiness. In our experience this is far from true. In fact the transformation of the toxic, painracked, bedridden, despairing patient before operation to the restful, painless, active, happy and hopeful amputee is one of the most gratifying experiences in surgery. Properly approached, nearly all patients will accept amputation when it is indicated; not one of ours persisted in refusing to submit, but one delayed about 3 weeks during which an unconquerable septicemia supervened.

INCOMPETENT CIRCULATION WITH INFECTION

The patient who has moderate cellulitis associated with ulceration or gangrene in an extremity with incompetent circulation may be treated conservatively for 24 hours or longer if improvement continues. He must be closely watched, however, for spread of infection, with frequent body temperature readings. When the patient's oral temperature rises to 101 degrees F. or higher, there exists so great a danger to the patient's life that we consider amputation mandatory, not as a leisurely procedure but as an emergency, as great or greater than an acute appendicitis. One of our amputations was done at 12:00 p.m. because of a sudden temperature rise to a dangerous level.

ANALYSIS OF CASES

Incidence. As one would expect, the conditions requiring thigh amputation are more prevalent in the age groups in which degeneration of arteries is more common. Thus we find 27 of 36 amputations in those over 60; 16 were in the 6th decade. Yet even the 4th decade is not exempt from the same process; only 1 of the 4 amputations was due to thromboangiitis obliterans. All 5 deaths in this series occurred in the patients over 60 (see Table III). Males predominate 2½ to 1 and the right side was amputated somewhat more often than the left.

Presenting symptoms. Outspoken ulceration or gangrene was the presenting symptom in 24 cases, pain and coldness in 6, and claudication in 4. The authors feel that a more painstaking history would have elicited previous complaints of coldness, numbness or claudication in a greater number.

Reason for amputation. Chronic ulceration or gangrene was reason for 34 amputations; 19 of these had spreading cellulitis. Two

amputations were performed for chronically infected below-the-knee stumps. In all cases the extremity was the site of well developed occlusive arterial disease.

Diabetic status. Twenty amputations were done on patients with diabetes. In 10, the diabetes was mild; in 3, severe. In 5, the presence of diabetes was discovered only on admission. The previous diabetic control in 13 cases was good or fair, in 2 it was poor.

There appears to be no important correlation between the grades of severity, duration or previous diabetic control, and the course after operation. The diabetics have been kept under strict postoperative control by the medical attendant. Thus, a severe diabetic of long standing, if properly controlled, seems to heal as promptly and with as few complications as the more recent and milder cases (see Table II). (The duration of hospitalization and days in bed are shown under a subsequent section.)

Peripheral pulses. It is remarkable that a dorsalis pedis pulse was felt in only one extremity, and this pulse only barely palpable. The posterior tibial was absent in all but 2; in 1 it was of normal force, in another barely palpable. The popliteal pulse was not felt in 24 cases, the femoral in one. We have always placed considerable significance on the character of the dorsalis pedis pulses in determining the presence of peripheral arterial disease. In many hundreds of examinations of the lower extremities for vascular disease, we recall no normal case in which the dorsalis pedis pulse was absent or markedly diminished. This was further brought out by Pearl and Kandel (13) who, in an estimation of the peripheral vascular status in 100 unselected diabetics, failed to find the dorsalis pedis pulse absent in feet with normal circulation. The converse, however, is not true. The dorsalis pedis pulse may be felt in extremities suffering from advanced degenerative arterial disease with some claudication and total absence of the normal vasoconstrictor influence. The posterior tibial pulse is at times impossible to feel in apparently normal extremities.

Absence of the popliteal pulse in 24 cases is noteworthy. Many of these arteries at operation were sectioned without appreciable bleeding. Despite this, most of the flaps healed *per primam.* This fits well the fact that the skin and subcutaneous tissues of the thigh and upper leg do not receive their blood supply from the femoral artery, but from the profunda femoris and the anastomoses around the knee joint.

Extremity pulse status. All pulses below the femoral were absent in 21 cases; every one below the popliteal in 10. In 1 case, the pulses were normal, in another none were felt. The presence of all pulses is not a guarantee that gangrene and infection will not occur or that amputation will not be necessary; nor is the complete absence of all pulses including the femoral a hopeless situation. One patient in the first category died of toe amputation followed by thigh amputation; one in the last enjoyed *per primam* healing.

Postural color changes. A definite degree of ischemia on elevation and rubor on dependency was present in every case. The author considers postural color changes as one of the most valuable tests in the determination of arterial insufficiency.

Calcification of arteries by x-ray. X-ray pictures were taken in 27 cases. The arteries cast shadows on the roentgenogram in 16; no shadows were noted in 11. The visualization by x-ray of calcification in peripheral arteries is unquestionable evidence of the presence of degenerative arterial disease, but failure to find calcified arteries is no basis for the denial of the process. Arteries may be completely occluded by a soft, degenerative process which casts no shadow on the x-ray film. On the other hand, the degree of calcification by x-ray is no criterion of the ability of the vessel's lumen to transmit blood. Markedly calcified shadows are often thrown by vessels which at operation are found to carry a goodly stream. Obviously then, calcium shadows cannot be used as a means of differentiation between thromboangiitis obliterans and degenerative arterial disease.

Preoperative days in hospital. In 20 cases, operation was performed 5 days or less after admission of patient. This is the result of a crystallization of our ideas as to what one might expect of conservative treatment and in the stabilization of our indications for ampu-

tation. It represents a great saving in time, money, and suffering over that in patients treated for many weeks under an indefinite regimen.

Preoperative temperature. In 20 cases the oral temperature was between 37.1 degrees C. and 38 degrees C. In 8, it was 37 degrees C. or less. Only 7 patients had fevers above 38 degrees C. The authors do not wait until high fever occurs before advising amputation. For this reason most of the preoperative temperatures ranged between 37 and 38 degrees C. The effect of temperature on the indications for amputation have been more fully discussed in a preceding section.

Postoperative days in bed and in the hospital. The average period of postoperative days in bed (12.4) and in the hospital (37.9) for all patients was much greater for diabetics than for non-diabetics. Thus 20 diabetics spent an average of 10 days in bed after operation, 16 non-diabetics 6; the hospitalization period for diabetics averaged 46.3, for nondiabetics 28. A large number of hospital days was piled up by 10 patients, 8 of whom were diabetic. Infection and necrosis of the stump were responsible in 5; in the remainder, other factors caused the delay. Since January, 1939, only 2 of 23 cases had hospital stays over 25 days, 1 due to the necessity for prostatectomy and the other due to coronary occlusion. The average hospital stay of these 23 cases was 20.7 days in comparison to the total average of 37.9 days. The number of days in bed over this same period has been greatly reduced to 4.6, far below the average of 12.4. The author is convinced that this improvement is due solely to greater experience and more mature judgment.

Treatment. All of the methods of treatment as shown in Table I were of course ineffectual in preventing amputation. The ideas of one of us in the management of peripheral arterial disease is set forth elsewhere (10). A few remarks regarding the fruitless treatment given to these subsequently amputated are pertinent.

The type of treatment given was determined on the basis of a complete vascular examination including estimation of the vasoconstrictor element in each case when possible. Suction pressure therapy and intermittent venous compression were ineffectual even when given for long periods. Ligation of the main vein was likewise unsuccessful. Lumbar ganglionectomy was done in one case of thromboangiitis obliterans which showed no vasoconstrictor element after posterior tibial nerve block; the thigh amputation in this case followed a leg amputation which lumbar ganglionectomy did not prevent. End-to-end arteriovenous anastomosis was done once for purposes of clinical research in a hopelessly affected foot.

TABLE I.—PREVIOUS TREATMENT
36 AMPUTATIONS

Ligation femoral vein or popliteal vein	3
Adequate (over 100 hrs.) suction pressure therapy	6
Peripheral nerve section	1
Hospital care only	4
Lumbar ganglionectomy	1
Papaverine hypodermically	2
Intermittent venous compression (over 500 hrs.)	4
Arteriovenous anastomosis (end-to-end)	1
Amputation 5th toe and head of 5th metatarsal	1
Amputation 1st toe and 1st metatarsal	1
No previous treatment	17

Lumbar ganglionectomy has a definite rôle in the treatment of vascular disease in extremities which retain a satisfactory vasoconstrictor element. One of us has utilized this procedure for the past 7 years with gratifying results. The failure to prevent amputation in the case here reported was partly due to poor selection. Cases for vein ligation should be also carefully chosen; those obviously ready for amputation should not be subjected to main vein ligation. As our experience widens we are leaning more and more toward early ganglionectomy as the most efficient means of preventing amputation in the well selected case. Not one of our patients with degenerative arterial disease who was subjected to sympathectomy in the proper stage has developed ulceration or gangrene. The technique developed by one of us (11) is simple and carries very little risk in trained hands.

Wound healing. The wound was considered as healing *per primam* if there were no drainage, inflammation, or necrosis by the end of the 14th day. In the operation as performed by us, drainage of serous material is expected for from 2 to 5 days and its presence does not indicate delayed healing. In several cases in which amputation was done since this report,

TABLE II.—WOUND HEALING—
36 CASES

	Cases	Total
Per primam, total		22
Diabetic only	11	
Nondiabetic only	11	
Delayed, total		14
Extensive necrosis of stump*	6	
Hematoma without infection	1	
Small necrosis at suture line	3	
Mild inflammation of subcutaneous tissues	2	
Persistent sinus	1	
Slight persistent drainage	1	

*Stump sequestra (4)

a further modification in technique, to be reported later, has decreased the serous drainage.

The number of delayed healings is far too high, and every effort is being made to decrease it. It may not compare favorably with the number healing *per primam* when other amputation methods are employed. Yet the most important single goal in amputation for peripheral vascular states is to save life. Our results realize this goal, not as completely as one would desire, but very satisfactorily in comparison with mortality percentages in many other reported series. The long mobile, end bearing stump and the absence of shock are features which no other method of amputation so well provides. Secondary operation on the stump is almost never necessary, whereas in guillotine amputations it is common. Many of those listed as "delayed healing" had comparatively minor complications which did not increase the period of preparation for or the ability to wear a prosthesis. All points considered, we are of the opinion that our method of amputation is far superior to the older methods.

Of the 24 patients who had no palpable pulses below the femoral vessels, 16 healed *per primam*. In this group, there was no noteworthy difference in wound healing between diabetic and nondiabetic. The cases of delayed healing were not more severe in one group than in the other.

When one looks at the causes of death (Table III), he notes that 3 patients died of complications not associated with the condition for which amputation was performed. It is difficult to see how these could have been avoided. One should take into consideration

TABLE III.—ANALYSIS OF 5 DEATHS
36 AMPUTATIONS

Case No.	Preoperative Temperature—Degree C	Age	Diabetes	Preoperative blood culture	Cause of death	Remarks
5	39.4	61	†	No growth	Infection and toxemia. Extensive stump necrosis	Refused thigh amputation for 2 weeks. Allowed toe amputation only
6	39.6	60	†	Positive for hemolytic streptococcus	Septicemia. Extensive infection and necrosis of stump	Blood culture positive before operation
19	39.4	64	0	No growth	Postoperative atelectasis and bronchopneumonia	Chronic coronary artery disease
25	38.0	72	0	Not done	Bronchopneumonia, postoperative	Chronic mitral and aortic valvulitis; chronic coronary artery disease
32	39.0	66	†	Not done	Pneumonia and cerebral thrombosis	Irrational and somnolent after operation. Stump healing *per primam* at death

their ages which ranged from 64 to 72 years and that 2 had previously suffered from coronary artery disease. A certain minimum number of deaths must be expected in patients of this age group in which degenerative changes in vital organs are usually widespread.

Two patients lost their lives as the end-result of the condition for which amputation was performed. One patient might well have survived if our plea for permission for thigh amputation had been heeded at once. We would be inclined in the future to refuse local amputation of an affected digit when in our judgment, the indications for the necessity of thigh amputation have been definitely established. The other patient was subjected to amputation a few hours after blood was taken for culture. Forty-eight hours later, the culture was reported positive for Streptococcus hemolyticus.

The total operative mortality of 5 cases in 36 (13 per cent[1]) is a great improvement on

[1]Percentage figures are purposely omitted to avoid the error which must appear in a small series.

the mortality reported by most authors and compares very favorably with the best statistics. The 3 deaths resulting from the general state and not associated with the condition for which amputation was performed probably represent the effect of degeneration in vital organs due to age or diabetes or both; the authors cannot suggest how this proportion can be reduced. Certainly, there is an irreducible operative mortality due to this cause. Of the remaining 2 deaths both could probably have been prevented if the patients had sought competent surgical advice earlier and if they had accepted the advice when and as given.

SUMMARY

1. The authors present their experiences with atraumatic amputation of the thigh in diseases of the peripheral arteries.

2. The indications for thigh amputation depend upon the circulatory balance of the extremity. Local surgery for foot lesions is contraindicated when the arterial circulation is incompetent. The authors outline their views of surgical treatment of ulceration and gangrene of the foot, with and without infection in relation to the circulatory status.

3. The reasons are given for the choice of thigh amputation which transects no muscles.

4. A statistical analysis of 36 amputations performed by the new technique is presented.

5. Wound healing was delayed more often than we would desire. The other advantages of the operation outweigh this disadvantage.

6. There were 5 deaths in 36 amputations. Two of these could have been avoided by earlier treatment. Three patients with marked degenerative changes died of pulmonary and cardiovascular complications. These 3 probably represent an irreducible mortality.

7. Lumbar ganglionectomy performed in the stage of satisfactory vasoconstriction is the most efficient means of increasing the peripheral circulation and in preventing amputation.

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FRACTURES OF THE ZYGOMA

A Report of 72 Consecutive Cases

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ALTHOUGH considerable has been written in medical literature in recent years concerning fractures of the jaws and nose, together with other facial injuries; there has been a noticeable lack of literature based on a comprehensive study of fractures of the zygoma and its component parts. This relative silence is certainly not the result of an infrequency of occurrence of this type of injury, as this paper will tend to show; nor is it due to any difficulty either in diagnosis or treatment by those trained in the proper handling of this condition. Undoubtedly, many such injuries are frequently "missed" merely because of lack of familiarity with the injury on the part of the examining clinician and do not become manifest to patients until some time after their occurrence.

Until fairly recently, and in fact even now to some extent, traumatic injuries of the face, especially those involving the bony framework, occupy a no-man's land in the field of surgery. The otorhinolaryngologist adequately cares for the acute fractures of the nasal bones, and the oral surgeon similarly serves quite capably in the care of acute fractures of the mandible and maxillae.

The exact field to which fractures of the zygoma belong is not so clear-cut or generally accepted. The writers have seen these cases cared for by both of the groups of specialists mentioned, and, in addition, by orthopedic and general surgeons, ophthalmologists, and, of course, plastic surgeons—especially those caring for maxillofacial injuries.

It is not within the realm of this paper to judge which group should control this field—nor would the writers so care to judge their colleagues, even if such were possible. Certainly, however, these fractures should be treated only by those properly qualified to offer the patient the best possible end-result.

Obviously, many men in various specialty groups have familiarized themselves sufficiently with the problems at hand, and, through their experience and understanding, are well qualified to render excellent treatment. The writers do, however, wish to call attention to the far too common practice of many, who, through lack of appreciation of the problem together with unfamiliarity with the methods of diagnosis and the treatment, have inadvertently and unwittingly often misguided the patient with the inevitable result of a marked deformity due to an obvious asymmetry of facial contour.

This is especially deplorable because the correction of the acute injury is, in most instances, a relatively simple procedure; whereas the late correction of these deformities, once healing has occurred, is often quite a formidable procedure and occasionally the results thus gained hardly justify any operative interference. Thus the patient often must go through life with a marked facial deformity which causes the individual more anguish and torture than could possibly be caused by many diseases far more menacing to life.

In addition, unreduced fractures of the zygoma may result in visual disturbances paranasal sinus disease, and interference with proper occlusion of the teeth. The latter may result in disease and poor functioning of the masticatory structures.

While injuries of the nature under discussion form a problem which cannot be overemphasized even in civilian practice; its occurrence and importance as result of modern war tactics will be increased manifold. This should be true not only of the actual overseas combat units, but also will become apparent in training centers especially where mechanized divisions are on maneuvers.

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Fig. 1. Fracture zygomatic arch. Before reduction by temporal approach.

Fig. 2. Fracture zygomatic arch. After reduction by temporal approach.

This paper represents a comprehensive study of 72 consecutive cases of fracture of the zygoma admitted to Kings County Hospital during the 3 year period from July, 1939, to June, 1942.

Admission to service. Although all cases of the nature under consideration are treated by the Plastic and Oral Surgical Service in Kings County Hospital, only 21, or 29 per cent, of the entire group were initially admitted to this service.

By far the largest group, 48, or 66⅔ per cent, were admitted to the Neurosurgical Service. This is readily understandable since so many of these patients suffered from head injuries or gave histories which made neurological observation for at least an initial period advisable. This is an important observation, for unless the neurosurgeon is familiar with the signs and symptoms, as well as the importance to the patient of early treatment of zygoma fracture, many of these cases will not be diagnosed until the resulting deformity becomes obvious to all concerned—and then, often, so much time has elapsed that the early, simple methods of reduction are ineffectual. Undoubtedly, considerable credit for "finding" many of these cases is due the house staff of the Neurosurgical Service whose keen interest in the problem and thorough examination of the patient resulted in the relatively high incidence of diagnosis of fractured zygoma.

Cause. Lothrop (1916) and Gillies and his associates (1926) called attention to the fact that zygoma fractures were always due to direct violence, and this has been substantiated by other reports. The findings in this series are entirely in agreement with these previous reports concerning etiology. This study indicated that the most important single cause was vehicle accidents—automobile and trolley, respectively—which constituted 31 cases, or 43 per cent, of the entire group. The next most important causes, in their respective order, were: first blows, 16 cases; falls, 8 cases, which were further divided into 4 cases in which patients fell as result of alcohol intoxication, 2 as result of epileptic convulsions, 1 slipped on an iced street, and another "missed" a step and fell headlong down the stairway; 5 patients were struck by foreign objects including baseball, 2 cases, baseball bat, 1 case, dishpan, 1 case, and lead pipe, 1 case. In 12 cases the cause was not determined for the patients were so intoxicated that no history was obtainable on admission to the hospital and even after recovery from this alcoholic somnolence, they either did not remember or gave such contradictory statements that no credence could be attached to their stories. For that reason it was thought best not to include them in this analysis from an etiological standpoint.

Thus, in the entire 72 cases, 43 per cent resulted from automobile and trolley accidents; 22 per cent from fist fights; 11 per cent were due to falls; 7 per cent due to blows by foreign objects; and 17 per cent were not de-

Fig. 3. Fracture of body before reduction. Arch intact. Infraorbital ridge depression.

Fig. 4. Fractures of body reduced. Intraoral approach.

termined. Naturally, if the latter group was not included, the percentage of each of the groups of known causes would be considerably higher.

Age. While, obviously, no age group would be immune to fractures, the youngest patient in this series was 14 years of age, and the oldest 65. However, 60 per cent of all the cases occurred in the age group ranging from 20 to 38 years. The average age of the entire group was 32.4 years.

Sex. Straith analyzed a group of automobile accident cases and found a marked preponderance of facial injuries occurring to the "driver's guest"—the person seated on the right side of the front seat. Most of these casualties were females. This latter finding is not in agreement with the statistical study of the 72 cases presented herein, which revealed that only 15 females suffered from fracture of the zygoma as compared with 57 males. This ratio of males to females affected is almost 4:1. Even considering only the 31 cases, or 43 per cent, resulting from automobile accidents and omitting the remainder due to other causes, there was still a marked preponderance of injuries in the male sex.

Side of injury. In 5 cases bilateral zygomatic fractures existed. In the remaining 67 cases, 52 occurred on the left side and only 15 on the right; ratio of left to right almost 3.5:1.

Number of fractures. Zygomatic fractures are usually multiple. In only 4 cases did a single fracture exist. Two fractures occurred in 28 cases, 3 fractures in 22 cases, 4 fractures in 10 cases, 5 fractures in 7 cases, and 6 fractures occurred in 1 case.

In 70 per cent of all cases patients had either 2 or 3 fractures. The average of all the cases was 3 fractures and the total number of all 72 cases was 207 fractures.

Site of fracture. The most frequent sites of the fracture together with the incidence of their occurrence are as follows: arch, 119 times; infraorbital, 44 times; frontal, 23 times; maxillary, 21 times.

Just as more than one fracture usually occurred in each case, so did a combination of 2 or more fracture sites occur in a single case. This was especially so with depressed fractures of the body of the zygoma.

Signs and symptoms. The most frequent signs and symptoms and their incidence of occurrence were as follows: (1) periorbital swelling and ecchymosis, 67 cases; (2) local tenderness on palpation, 67 cases; (3) palpable depression or irregularity of contour, 61 cases; (4) pain—constant, 59 cases; (5) pain on mastication, 49 cases; (6) asymmetry between left and right sides on finger palpation intraorally between ramus of mandible and the maxilla, 46 cases; (7) epistaxis, 45 cases—39 of these 45 were associated with depressed fractures of the body of the zygoma injuring the antral mucous membrane. Only 2 such fractures failed to produce epistaxis. On the other hand only 6 of 31 cases of arch fracture experienced epistaxis; (8) sensory changes over distribu-

tion of infraorbital nerve ranging from parasthesia to anesthesia, 35 cases, all of which were associated with depressed fractures of the body, none with fractures of the arch alone; (9) conjunctival hemorrhage, 34 cases; (10) visual disturbances, diplopia, 18, blurred vision, 7—25 cases; (11) visible depression, 23 cases; (12) headache, 16 cases; (13) drooping of face and lip, 14 cases; (14) difficulty in opening mouth, 12 cases; (15) dizziness, 11 cases; (16) anesthesia over distribution of infraorbital nerve, 4 cases; (17) mobility or crepitus, 3 cases; (18) subcutaneous emphysema, 2 cases.

Associated injuries. Due to the location of the zygoma and its component parts, the nature of the accident, and the force necessary to cause its fracture, it is to be expected that other injuries often might occur associated with these fractures. Practically all of the patients showed evidence of local contusion. Nineteen, or 26 per cent, suffered from cerebral concussion; 16, or 22 per cent, had lacerations of the cheek or face (very few of these communicated with the fracture site, however); 10, or 14 per cent, had fractured mandibles including 3 cases of fracture of the coronoid process which is one of the rarest fractures of the mandible; 9, or 12.5 per cent, had fractured nasal bones; and there were 8, or 11 per cent with fractured maxillae.

Time of operation. Admission to hospital ranged from a few minutes to 12 days following injury. The average was 32 hours. This meant that even without any serious associated injuries some of the patients were not operated upon immediately due to the amount of swelling present. In addition, as previously stated, in only 29 per cent of these cases were patients initially admitted to the plastic service. Therefore, there was even more delay in time consumed by consultations between the services, x-ray studies, and the like.

However, in spite of this, all patients requiring operation were operated upon from 2 hours to 2 weeks following the injury. Eighty-five per cent of all operations were performed in the period from 2 to 6 days following injury. The average time after injury for all cases was 4.1 days.

Reduction of fracture. In general, fractures of the zygoma should be reduced immediately, before swelling begins, or, if that is impossible, it is better to wait 5 or 6 days until the swelling subsides. Ice compresses or other similar local aid in prevention of swelling may be used.

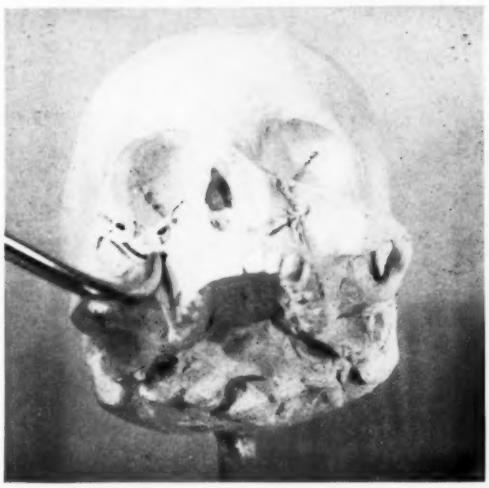

Fig. 5. Diagram of intraoral approach.

Obviously, there are many approaches to any operative procedure and it is not the purpose of this paper to attempt to convert one from his tried and proved method of reducing fractures of the zygoma and its component parts to the methods which have proved the most satisfactory to the writers. In any given case certain advantages and disadvantages are readily recognized with all of the methods of approach, and the final decision must be determined by the nature of the injury and the personal experience of the operator.

We favor two methods of approach, for these have afforded the best results in our hands. Each has its place, and either one or the other method usually is best suited for the particular injury at hand and is used, therefore. Occasionally a combination of injuries may necessitate the use of both methods in the same case to effect the best results.

The temporal approach, first described by Gillies and associates was used to elevate into position the depressed fractures involving only the arch, or even the body in cases in which the fractured fragment had sufficient posterior projection to enable an instrument to be en-

Fig. 6. Diagram of temporal approach. Fracture of arch.

Fig. 7. Replacement of arch. Temporal approach.

gaged behind it and provided the wall of the maxillary sinus had not been too badly comminuted and depressed into the antrum. This method, based upon an anatomical study of the superficial temporal fascia and its relation to the zygomatic bone and its component parts, has the advantage of being performed through a sterile operative field which no oral or nasal method can claim. Also, with the incision being placed above the hairline, no visible scar results. It is a simple procedure, easily and quickly performed, and the chances of complications are minimal. While this was considered the method of choice wherever feasible, it has its limitations.

In those cases in which the force of the blow caused the body of the zygoma to be driven downward and into the antrum with lowering of the infraorbital ridge and multiple depressed fragments of the wall of the maxillary sinus itself—the temporal approach proved ineffective.

A counter-force directed from within the antrum to elevate and re-deposit the depressed fragments into their original position, and at the same time to drain the antrum was deemed the method of treatment. In this series of cases the antral approach was performed exclusively through the vestibule of the mouth as for a Caldwell-Luc operation, rather than through the nose as used by Shea, Watkins, and others.

In all instances in which the antral method was employed, a careful search following incision of the mucoperiosteum over the sinus wall revealed an opening into the antrum, at the fracture site, sufficiently large to permit a medium size curved urethral sound or any similar blunt instrument to pass within the sinus without further enlarging the opening.

Complications. The only untoward complications encountered in all the operations was hemorrhage. This occurred in 2 cases during the operative procedure. In both instances the fracture was relatively "old" (12 days and 14 days, respectively). The instrumental "breaking up" of the early healing fractures resulted in injury to branches of the internal maxillary vessels. In both cases packing was employed to arrest the hemorrhage, and in one of these cases, the hemorrhage recurred 2 days after operation necessitating the repacking of the wound. Neither patient suffered from shock, and both made excellent recoveries.

Operative cases. Of the 72 cases, 42 were operated upon to reduce fracture, 30 were not. Of the latter nonoperative group 12 signed their release from the hospital against the advice of the attending surgeon. This group included mainly alcoholics on the neurosurgical service. Two of these returned 6 months to a year later and now will require more complicated and less desirable procedures to correct their deformities.

Among the 42 who had reductions, the selected operative approach in 24 cases was through a temporal incision; in 14 cases the antral approach through the vestibule of the

mouth was used; 2 patients required a combination of temporal and antral elevation; and 2 patients were reduced through the oral approach posterior to the antrum without opening the latter.

Of the 14 antral approaches 8 required packing of the sinus to maintain the elevation of the fractured fragments. This original packing remained in place 8 to 14 days and was then removed and the antrum was not repacked.

All of these patients were closely followed by postoperative check-up examinations. The shortest "follow-up" period of observation was 5 months and the longest 15 months, average of the 8 cases being 9 months. These periodical examinations included history, physical examinations, and sinus x-rays. In no instance were there any signs or symptoms of sinusitis; nor was there any x-ray evidence of any infection.

Postoperative course. The number of days spent by the patients in the hospital following the date of operation varied greatly depending primarily upon the nature of the associated injuries rather than upon the local injury under discussion. However, even the latter influenced this postoperative convalescence to a definite degree. One patient, who suffered multiple and bilateral fractures of the pelvis, tibia, femur, os calcis, and mandible was in the hospital 13 months. On the other hand, patients having no serious injuries other than fracture of the zygoma were discharged in from 1 to 14 days later.

The operative procedure employed, which was determined by the site and nature of the fracture, definitely modified the postoperative course. Those patients requiring reduction of the fracture through the antral approach, draining, and packing of the maxillary sinus remained in the hospital longer, ran a slightly higher temperature, and for a somewhat longer period in general than did those in whom the temporal approach was used (Table I).

One explanation for the discrepancy in so far as the period of hospitalization is concerned, is that it is quite possible that we may have erred on the side of conservatism in not permitting the patient to be discharged until the packing placed into the antrum had been removed. Thus hospitalization was prolonged, but the end-results seem to have justified this practice.

TABLE I.—POSTOPERATIVE COURSE

	Temporal	Antral
Postoperative days of hospitalization	1–6	4–14
Average days	3	7
Highest postoperative temperature recorded—degrees	100.2	100.8
Longest postoperative temperature elevation—days	3	5
Average postoperative temperature elevation—hours	24–36	48–72

There was not one single case of postoperative infection in the entire series.

External approaches besides temporal. The external approaches besides the temporal include: (1) elevation of depressed bone by use of a tenaculum, a cow-horn dental forceps, or a towel clamp through the skin to grasp the bone (Gill); (2) the Collins slip-lock (Patterson); (3) the Hagedorn needle, thread and copper wire (Matas); (4) a corkscrew-shaped instrument passed into the bone and traction then used (Roberts); (5) a hook passed beneath fragment through small nick in the skin (New).

Intraoral methods. The intraoral methods include: (1) a small incision in mucobuccal fold above the second molar. An elevator introduced and carried beneath malar bone, and is elevated with the maxilla as fulcrum (Goldthwaite, Straith); (2) the antral as practiced by Lothrop, Blair, Ivy, Naftzger.

Nasal approach. The nasal approach is accomplished by means of (1) a Ritter sound through the intranasal antrotomy (Shea, Watkins); or a clot is displaced by means of vaseline gauze and the gauze is then withdrawn.

Immobilization. Immobilization is accomplished (1) with a drill hole, wire, or head cap (Kazanjian); (2) with a conical thread screw (Akerman); or (3) by direct wiring.

SUMMARY

1. This report includes 72 cases of fracture of the zygoma treated by the authors. In 85 per cent the result was excellent and in all of these cases operation was performed within 2 to 6 days after injury. In the 15 per cent remaining there was considerable improvement; in these the operation was done late.

2. Two methods of operative approach have proved most useful in reducing these fractures: the temporal and the intraoral.

3. Packing the antrum and allowing the packing to remain 8 to 14 days apparently caused no harm.

4. Reduction should be attempted no later than the 6th to 10th day, whenever possible.

5. Early operative reduction is a relatively simple procedure. Late operative reduction is more formidable.

6. Postoperative infection was extremely rare.

7. Early diagnosis contributes greatly to successful reduction.

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THE SULFANILAMIDE OINTMENT TREATMENT OF SEVERE BURNS

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FOUR general problems confront the surgeon treating a patient with a severe widespread burn: (a) shock produced by local plasma loss, (b) "toxemia," (c) the prevention of infection, and (d) early grafting of the burn surface should this prove necessary. Concerning the prevention or treatment of shock, there is now general agreement that administration of plasma is exceedingly beneficial. Of "toxemia," we know little as to causes or treatment, except that recent evidence indicates that tannic acid is definitely a hepatotoxic agent. Of the third problem, infection, it is believed that the most fruitful method of solution has been meticulous care in "the conversion of the open contaminated wound into a clean wound" by proper cleansing, excision, and dressing.

It should be kept in mind by all who must treat a burn that no matter what the physical or chemical characteristics of the ointment or spray to be employed, the agent applied to the burn surface should possess certain qualities: (1) It should not produce toxic effects, local or systemic; immediate or delayed; (2) if possible it should be somewhat bacteriostatic; (3) it should permit early mobility of joints and flexor surfaces, if this is desired; (4) it should not injure remaining viable epithelial elements that would produce early epithelization; (5) it should inhibit plasma loss (in second degree burns); (6) the method of application should possess a certain flexibility and simplicity, without sacrifice of fundamental principle, to allow for the treatment of mass burn casualties, either civilian or military.

In this paper we wish to outline a method for the local treatment of severe burns which possesses most of these qualities and which employs nothing more in the local therapy than the application of a simply prepared and simply applied oil-base sulfanilamide ointment. The method can be easily adapted to mass casualty use, either civilian or military. This paper will deal only with the immediate primary treatment of the burn surface. What we have learned relative to the subsequent care of severe burns will be discussed in a separate communication.

All burned patients considered in this paper were severely burned and were hospitalized. In general, the average burns covered about 15 to 20 per cent of the body surface, many in the neighborhood of 40 per cent, and 1 approximately 75 per cent (Fig. 1, a). A large percentage (39%) of the burned patients were children. The depth of the burns can be judged rather easily in that 36 per cent required grafting. One hundred and twenty-six patients were treated by the method to be outlined; in this group there are 3 deaths.

Sulfonamide ointments have been reported by others to be useful in burn therapy. Allen, Owens, Evans, and Dragstedt (2) treated 2 patients with severe burns with recovery, and Gurd, Ackman, Gerrie and Pritchard have treated 31 "major burns" with a sulfathiazole emulsion with excellent results. There has been a considerable and sometimes not entirely understandable hesitancy on the part of many surgeons to use sulfanilamide locally in wounds. In Dr. I. A. Bigger's clinic[1] in this institution sulfanilamide has been used locally in several thousand potentially infected wounds since 1938. All of us here are now absolutely convinced of the wisdom of this treatment; in its local use in burns we have simply applied the lessons learned in other types of wounds.

SULFANILAMIDE OINTMENTS

The sulfanilamide ointment used in these burns is of simple composition, is inexpensive,

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Some of the work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development, and the Medical College of Virginia.

[1] Dr. Bigger, chief of surgery, arranged facilities which made this work possible and gave freely of both his time and most appreciated critical judgment.

and is easy to prepare. We wish to state emphatically that what we have to say regarding the use of sulfonamide ointments in burns applies only to one type of ointment, namely, that which employs a *fatty* base. We shall report elsewhere our studies on a series of burn patients in which a comparison was made of relative absorption of sulfonamides from a fatty or water-dispersible base. It is necessary to report here only that dangerously high blood levels of sulfonamides were obtained when the water-dispersible base was employed in burn therapy.

The sulfanilamide ointment used is made from equal parts of sterile lanolin and cold cream to which is added, by thorough dispersion, sterile sulfanilamide powder to a 6 per cent concentration by weight. Absorption of sulfanilamide from this fatty base must be very limited and slow, blood levels being in the neighborhood of 1 to 2 milligrams per cent for days after the ointment has been applied to the burned surface.

Sulfanilamide, rather than sulfathiazole or sulfadiazine, has been used because it has been our experience that we see less severe unfavorable reactions with sulfanilamide than with the other two sulfonamides. Further, it has been so effective that we have not felt it necessary to use these other drugs.

PRINCIPLE OF SULFANILAMIDE OINTMENT THERAPY

No matter what treatment is used for the burn locally, every attempt should be made to prevent or treat shock. Plasma lost in the initial hours after the burn has been received should be replaced to the extent that shock is prevented. It may be considered heresy but we have come to pay little attention to the application of mathematical formulae introduced by others to calculate plasma needs in an individual burn case. Our experience in this fairly large series of severe burns, supported by careful daily estimations of plasma volume by the dye technique of Gregersen, indicates that it is very wasteful of plasma to attempt to restore plasma volume fully before the 40th to 70th hour after the burn has been received. In general we have attempted to give plasma in 250 to 500 cubic centimeter amounts in the first 24 to 36 hours no matter what the extent of the burn, except in those patients in whom shock was present or impending. Hematocrit determinations are made every 6 hours; an attempt is made to keep the hematocrit levels in the neighborhood of 50 to 52 during the first 2 days. This has demanded a more careful watching of many patients, but much plasma has been saved and only 4 instances of shock have been noted. (One in the 75 per cent burn; he received large amounts of plasma.)

We have become enthusiastic advocates of the Koch-Allen (1) principle of pressure dressings to the burned areas. These dressings have been applied in the great majority of burns treated in this series; this may account in large part for the low incidence of shock in the first 36 to 40 hours.

We are in such accord with the general principles of burn therapy outlined by Allen and Koch that it is unnecessary to go into detail of the background of the sulfanilamide ointment treatment of burns. Briefly, every effort is made to convert the contaminated wound into a clean wound by proper excision of easily removed necrotic tissue and proper gentle cleansing of the burns with simple soap and water[1]. Every person coming in contact with the burned patient is obliged to wear a mask, thus preventing mouth-borne infection (hemolytic streptococcus). Locally applied sulfanilamide, slowly absorbed, prevents infection; early repair of epithelium is possible only when infection is absent. Pressure dressings reduce plasma loss, and in conjunction with splinting, afford proper rest for the injured part. Primary dressings are left in place 7 to 9 days so that time is afforded for natural repair of the burned area.

TECHNIQUE

In the series of photographs (Fig. 2a-g,) we illustrate the details of the sulfanilamide ointment treatment of burns. All burn patients are cared for from inception of the burn to the end of the treatment, including skin grafting, by a "burn and shock team." When the

[1]We have made exceptions to this rule in very severely burned patients. Here only a rapid, sometimes cursory cleansing and excision is done, perhaps while plasma is being given to the patient during the impending shock period.

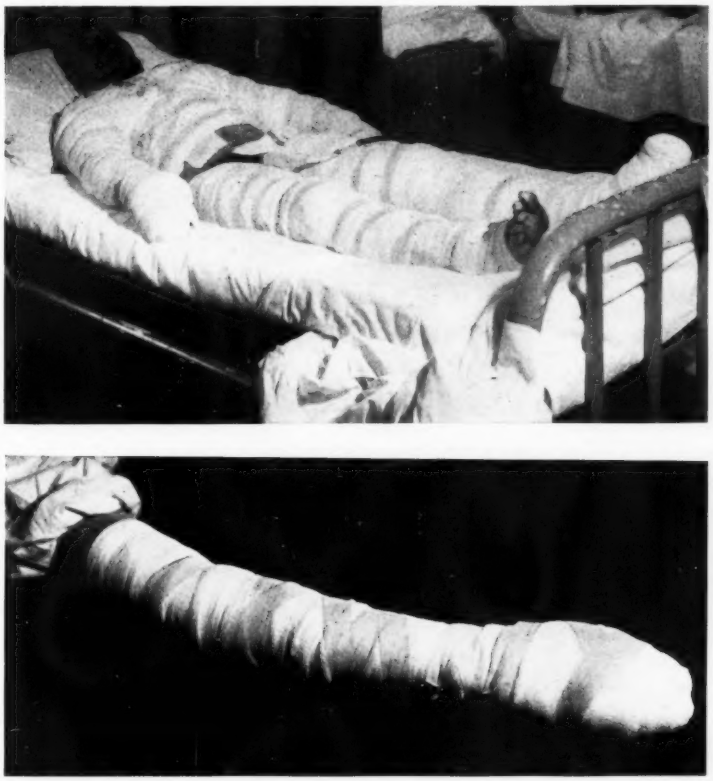


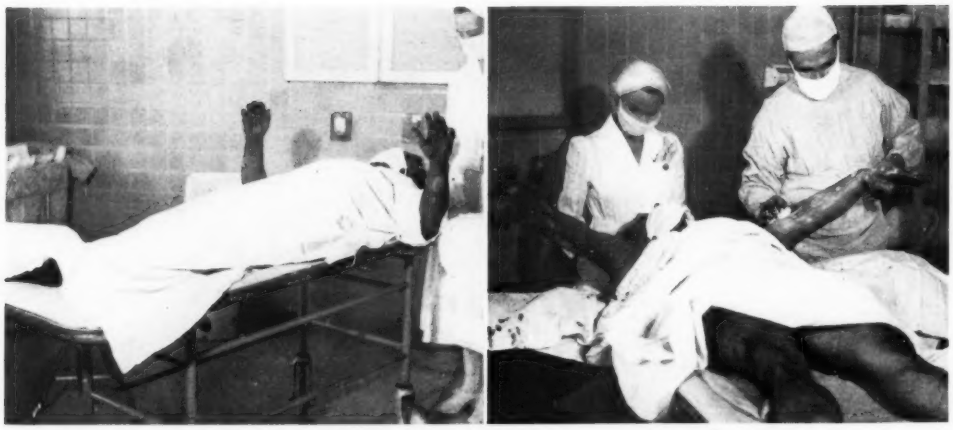
Fig. 1. a, above, Patient with dressings applied to almost entire surface of body. b, Appearance of arm in pressure dressing.

patient is admitted to the emergency room (Fig. 2a), he is given morphine immediately in adequate doses (adults grains ¼) to allay pain. Recently we have been using sodium luminal with morphine. No other anesthetic is allowed. Attendants and patient are immediately masked to prevent mouth-borne infection. The patient is placed on a stretcher and covered with sterile sheets and towels.

The patient when quiet and free from pain is taken to the operating room (Fig. 2b), where the burned areas are gently washed with copious quantities of white soap and sterile saline by members of the burn team who have prepared themselves as for any operation employing aseptic technique.

Once the burned areas are clean, excision of easily removed dead skin is begun (Fig. 2c). No obvious dead tissue is left, but an attempt is made not to injure healthy tissue. Figure 2d illustrates the extent of excision in one hand of this burned patient.

When the burned areas are thoroughly cleansed and débrided, a liberal quantity of the oil-base sulfanilamide ointment is applied to all burned areas (1st, 2d, and 3d degree) with a tongue blade (Fig. 2e). Almost as soon as the burn surface is covered with sulfanilamide ointment the patient states he is relatively free of pain. The anesthetic property of sulfonamide ointments has been mentioned by Gurd and associates. It is not necessary to add any other local anesthetic agent to this ointment. Sterile surgical compresses are placed over the ointment (Fig. 2f). Fingers are individualized. Next a pressure dressing



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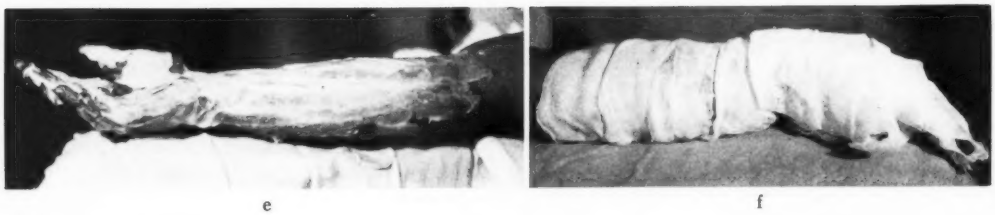

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Fig. 2. a, Patient is placed on sterile sheets and given adequate doses of morphine so that all pain is relieved. If the burn is widespread the initial dose is usually ½ grain morphine in the adult. All nurses and doctor attendants in the emergency rooms are masked. b, With no other anesthetic than morphine administered, all burned areas are washed gently with white soap and sterile water under strictly aseptic conditions. If possible, this is done in the operating room. c, Blebs are opened and the dead skin is removed by scissors or

(*See opposite page*)

is applied. We have used gauze rolls, surgical bandage, and Ace bandages, but for general use have come to like the regular "leg" roll best of all of these for application of pressure. Care must be taken not to attempt too much pressure, lest nerve injury result.

After the pressure bandages are in place, the patient is put in a bed on sterile sheets, and proper splinting of arms or legs carried out (Fig. 2g). Both wooden and plaster splints have been used.

The same treatment is used for all parts of the body that may be injured by the burn; this includes the so called critical areas, face, hands and genitalia. In the early part of this study, pressure dressings were applied to the face; we no longer do this, since the edema of the face seems to recede by the 4th day whether or not pressure dressings are used, and the patients complain less when the face pressure dressing is not employed.

If a burn is seen late or is infected when first seen, the method here outlined is not used. Instead, warm continuous saline compresses are placed at once on the burned areas and these are used until the burned areas are surgically clean. If the infection is severe, sulfathiazole is given by mouth and sulfanilamide powder is used locally.

OBSERVATIONS WITH SULFANILAMIDE OINTMENT PRESSURE THERAPY IN SEVERE BURNS

Shock. As mentioned, shock has occurred in only 4 patients in this series. More cases of "shock" may have been present, and simply not observed. It may well be that the criteria used for shock (low blood pressure, rapid pulse, poor venous filling time, etc.) are inadequate in the study of shock in burns. Our patients are usually seen quite early (½ to 1 hour) after the burn is sustained, because of a well organized city ambulance service, so that pain is quickly relieved. Plasma is given early after admission. We are inclined to believe that the early application of the pressure dressing has diminished the incidence of shock.

Toxemia. We had treated earlier a number of burned patients by the tannic acid silver nitrate method. We have been surprised at how much less "toxemia" has been observed in patients treated by the sulfanilamide ointment method, than when tannic acid was used. There is no doubt that some of our severely burned patients have been "toxic" during the first 3 to 5 days following the burn, but the number has been small. We are aware that when large areas of 3d degree burn are sloughing the patient may appear toxic, the appetite may be poor, and the temperature elevated to 101 to 103 degrees F. If daily saline baths are started soon and the slough separates early, the "toxic" period is short. We are inclined to the view that patients may show some toxemia as long as the slough remains. This we believe is not due to the absorption of a specific burn toxin, but rather to absorption of split-protein products formed by the disintegrating, sloughing tissue.

In 15 severely burned patients, prothrombin times were estimated daily during the first 3 to 4 days following the burn. There has been no evidence of severe liver damage in this series, the prothrombin time of the burned patients closely approximating the controls (usually control 15 seconds, burn 18 seconds). Jaundice has not been observed in this series. Any nitrogen retention has been relieved, usually after about the 3d day.

The fact that no general anesthetic was given to any of these burn patients may account in part for the relative absence of toxemia.

A sulfanilamide "rash" appeared in 3 patients. This was relieved when the sulfanilamide ointment was removed and the sterile vaseline was applied. The relative absence of systemic reaction to sulfanilamide is due, we believe, to the very limited absorption of the drug from the burn surface when the fatty base is used.

knife excision. Care is taken not to injure healthy, normal tissue. In military surgery this step need not be employed if time and personnel are not available. d, This photograph illustrates the amount of dead skin that was removed in the burned hand of this particular patient. e, The fatty base sulfanilamide ointment is spread in a thick layer over all the burned surface. As soon as the ointment has been applied any residual pain is relieved. f, Sterile gauze compresses are placed over the sulfanilamide ointment. Fingers are individualized. g, After all the pressure dressings have been applied the patient is placed in a bed with sterile sheets. Arms and legs that have been burned are splinted for several days. This primary dressing is not removed for 7 to 9 days, depending upon the amount of 3d degree burn and subsequent discharge.

Fig. 3. This photograph illustrates the results obtained in the use of sulfanilamide ointment in the treatment of widespread 2d degree burns in a 9 year old child. The outlined (burned) area was covered with large blebs which were removed at the initial dressing and sulfanilamide ointment was applied. The photograph was taken immediately after removal of the primary dressing on the 9th day. All of the burned area was practically healed and the patient was discharged on the 11th day.

Cyanosis has not been observed in any burn case when the fatty base was used, but was a common complication in the studies in which the water-dispersible base was employed.

Infection in burns. Allen and Koch have presented this problem well when they state that "for years past, infection has hung over the head of the burned patient like the sword of Damocles." To our minds, there is no more important matter in the care of burns than the prevention of infection.

No quantity of a bacteriostatic drug such as sulfanilamide applied locally can prevent infection if overwhelming numbers of bacteria are implanted on the wound. This demands that great care be taken by all who come in contact with wounds (especially burns), *carefully to mask themselves* and make certain that their hands and their surgical instruments are free from pathogenic bacteria. In 2d degree burns it may be well to remove with great care all superficial skin that is obviously dead, but it is simply foolish to speak of "thorough deep excision of all dead tissue" in 3d degree burns as a primary step in the treatment of such severe burns. It is our belief that most burned patients will not tolerate this added trauma. Thus the intention of one treating a burn should be to prevent, so far as is possible, infection of the burned area by mouth and nose-borne organisms (proper masking) and by ordinary pathogenic bacteria found on unclean hands and instruments (soap and water cleansing, gloved hands, sterile instruments).

Fig. 4. a, left, A deep burn of the arm and hand caused by a gasoline explosion. This photograph illustrates the appearance of the burned area after removal of the primary dressing on the 7th day. Numerous islands of epithelium can be seen intact. Sulfanilamide ointment plus pressure was again used in this patient. b, Illustrates the appearance of this arm after the removal of the second dressing on the 18th day when the burn area was practically healed. The patient was discharged on the 22d day with perfect use of the hand and arm. It was in this patient that there was persistent plasma loss despite considerable pressure used in each dressing.

Figs. 5. a and b, Illustrate the degree of healing seen on the removal of the primary dressing in the hands of the patient illustrated in Figures 2, a to g, on about the 10th day after the burn had been received. It will be seen that there is rapid healing of the burned surface with normal flexion of the fingers.

There have been a few instances of infection in this burn series in which Streptococcus pyocyaneus and Staphylococcus albus have been cultured. These occurred late in the therapy of 3d degree burns, and were easily controlled by simple measures. It is noteworthy that there has been no single instance of *any* type of infection in any severe superficial or deep 2d degree burn in this series, nor any single instance of infection by the hemolytic streptococcus in any burn in this series. Proper masking, strict surgical asepsis, and meticulous care are in no small part responsible for this result, but we are firm in our conviction that some credit should be given to the local application of sulfanilamide.

Healing time of burns. The average superficial 2d degree burn is found to be healed when the first dressing is removed on the 7th to 9th day (Fig. 3). The deep 2d degree burn requires further dressing but is usually well healed by the 14th to 18th day (Fig. 4a-4b). The prompt healing of second degree burns has ceased to be a problem in this hospital since we began the use of this treatment.

The healing of 3d degree burns largely depends on the time it takes for the slough to separate, and healthy, clean granulation tissue to form, so that skin grafting may be begun. For small areas this may be as early as 14 days with the treatment outlined, but when large areas (30 to 40%) are involved we have often been discouraged to note that 4 to 5 weeks have passed before skin grafting could be undertaken. So far as we can determine, the sulfanilamide ointment therapy (or simple vaseline) in no way delays or hastens the time when skin grafting may be done in a 3d degree burn. We do believe, however, that tannic acid therapy definitely brings a delay because of the slowness of the slough to separate, in some cases.

There have been those who state that locally implanted sulfanilamide delays the healing of a wound. Our experience (and that of Gurd and associates) with sulfonamide ointments in 2d degree burns causes us to believe that we could hardly expect more rapid healing of the burned area. Also, we have applied the test suggested by Cannon and Cope and find that when dermatome grafts are cut at 0.012 inch thickness, and our fatty base sulfanilamide ointment, boric acid ointment, and vaseline applied to certain areas of the donor site, all areas heal at the same rate. Here there is no indication that this type of sulfanilamide ointment delays wound healing.

Local plasma loss. Many of the advocates of the tannic acid method for the treatment of 2d degree burns use that method because they feel that with no other method does one obtain such rapid cessation of local plasma loss. We are rather inclined to accept this point of view if one in considering "superficial" 2d

Figs. 6. a and b, This child was burned on the face, chest, hands and forearms by boiling water. a, Illustrates the appearance on admission to the emergency room; b, the degree of healing 3 days after removal of the primary dressing (10th day). The granulating sites were grafted early and this patient was discharged on the 29th day after entry

degree burns which may "weep" badly, but we have been surprised to learn in this study that in only 1 case (Fig. 4a) were we troubled with persistent local plasma loss once the sulfanilamide ointment had been applied to the débrided burn surface. In all cases except the one mentioned, no further troublesome plasma loss occurred.

It may be that we have been dealing mainly with deep 2d and 3d degree burns. Certainly the accounts given us by naval medical personnel of local plasma loss in certain "flash burns" would cause us to suspect that no local burn therapy but tannic acid (or another escharotic method) would prevent serious plasma loss in this type of 2d degree burn.

Plasma loss in the 3d degree burn is another matter. In our experience, there is practically *no* external loss of plasma in 3d degree burns; the loss there is the "white hemorrhage" of Allen and Koch, plasma lost into the subcutaneous tissues under the burn. It is in the 3d degree burn that one sees the poorest results when tannic acid is used. To us it seems wholly illogical to cover the surface of a 3d degree burn with an heavy eschar to prevent plasma loss. The net result is no decrease in plasma loss, but one is left with a heavy eschar which acts almost as a barrier to the escape of products of the degenerating skin beneath the eschar. "Surgical drainage" of the "wound" cannot take place. It is no wonder that such eschars almost "float" on the burn surface after a few days.

The critical areas. It is with severe burns of the hands and face that our results with the sulfanilamide ointment treatment of burns have been so gratifying. Given an opportunity for natural repair without having to overcome undue therapeutic hazards and obstructions, hand injuries do amazingly well (witness the published photographs of Kanavel, Mason, or Koch in extremely severe trauma to the hands). We believe that the greater proportion of hand burns will do equally well if treated with sulfanilamide ointment. With this treatment, the 2d degree burned hand can be mobilized immediately after the removal of the primary dressing. Third degree burns of the hand can be grafted at quite an early date.

We have not hesitated to use the treatment outlined on trunk burns. From a dressing standpoint, these cause us the most trouble. Nevertheless, the results have repaid us for the many hours devoted to dressing these patients. Figure 5a and b illustrates results of a hand burn which was treated by this method. The face burns do equally as well (Fig. 6a and b).

THE SULFANILAMIDE OINTMENT TREATMENT OF BURNS IN MILITARY PRACTICE

The foregoing was written from the civilian surgeon's point of view and experience. In military and emergency practice, certain details of this (and other methods of) treatment will have to be sacrificed simply because of the rush of events, mass casualties, and insufficient personnel. It is our belief that the simple ointment method outlined here is worthy of consideration in any attempt at solution of the problem of how best to treat burns in military practice. In certain military zones of operation, it will be impossible to do much more than examine and treat rapidly the burned patients. Here, excision of bleb skin, etc. may be considered unwise and unnecessary. The military surgeon in the forward areas would do well simply to apply the sulfanilamide ointment (fatty base), preferably from tubes, spread it over the burn surface and cover the area with sterile gauze and bandage. If pressure dressing supplies (and time) are available, they should be used. This primary emergency dressing should be left in place until the patient reaches a base hospital, where it may be removed and definitive treatment carried out. It may prove to be unnecessary and unwise to remove this primary dressing before the optimum time, even to carry out a more detailed treatment. The main principle to be kept in mind is to cover the burned areas with sulfanilamide ointment and an occlusive dressing to prevent infection.

One of the chief disadvantages to the simple vaseline ointment treatment of burns in military practice may be its requirement on oral administration of the sulfonamides during the initial days after the primary dressing, often in situations of war where the sulfonamides, water, and the personnel for administration may be altogether lacking.

In naval medical practice, sulfanilamide ointment (fatty base) may be stored in jars in certain quarters of the ship, to be applied by any available personnel (or the patient himself), if the sick bay is blown out.

For military purposes, the primary treatment of burns here outlined, if carried out only in its barest essentials, lends itself admirably to the problem of adaptability to any given military situation. Its use in aviators' hand and face burns should prove to be superior to any of the tanning methods. In short, for military use, the method is simple, inexpensive, requires limited equipment, personnel, and time, and offers promise of giving excellent functional results in the treatment of severe burns of every type.

SUMMARY

A method of treatment of severe burns which employs sulfanilamide fatty base ointment as the primary dressing has been presented. In our hands it has given excellent results, with a low death rate. It is simple and easy to apply. Its relation to the problem of the treatment of burns in military surgery has been discussed.

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WOUND HEALING—EXPERIMENTAL AND STATISTICAL STUDY

IV.—Results

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IN catgut sutured wounds it was found that during the lag period there were no statistically significant increases in tensile strength from one day to the next, nor were there any significant decreases.

Among the nonabsorbable sutures, statistically significant increases and decreases in tensile strength were observed in silk and cotton sutured wounds, but only decreases in wire and nylon sutured wounds (see Graph 6). The lag period was longest for catgut and cotton sutured wounds, being of 4 days' duration, for silk and wire sutured wounds, 3 days. For nylon the lag period was the shortest—2 days (see Tables IV, V, VI, VII, and VIII).

There was one confusing factor. The lag period in cotton sutured wounds displayed a characteristic not seen during the lag period of any of the other nonabsorbable sutured wounds, namely, a significant decrease in tensile strength by the 3d day, followed on the 4th day by a nonsignificant increase, and then a significant increase. Thus, there was an interval of 1 day in which there was a nonsignificant increase in tensile strength, until a significant increase was noted.

On the other hand, in all wounds sutured with any of the other nonabsorbable materials, there was a significant decrease in tensile strength characterizing the end of the lag period, followed immediately by a significant increase.

Since the same technique was used throughout the experiment, obviously the only variable that could exert a causative influence was the type of suture material used. From the point of view of shortening the lag period in order to accelerate final healing, the results so far would seem to indicate that a nonabsorbable suture is preferable to catgut, and of the nonabsorbable sutures it would seem that nylon is to be preferred over the others.

Howes and Harvey[1] have indicated that interpretation of the tensile strength of wounds during the lag period is open to question, since the results obtained are dependent upon the type of suture material used. It appears to us that an increase in tensile strength associated with a particular type of suture material should be taken into consideration.

In the groups studied the lowest point on the curve of tensile strength occurred at the termination of the lag period (see Graph 6)[2]. Following this period, the gain in tensile strength was progressive and was coincidental with proliferation of connective tissue. This was to be expected since this is the interval just preceding the beginning of fibroplasia, and probably at this time also the suture material has been weakened by the reaction of the wounds. Moreover, the tissues adjacent to the suture material have probably suffered from trauma. Tissue reaction is decreased and holding power of the tissues is lessened.

The limiting factor in testing the tensile strength of wounds in the post-lag period by the method outlined is the tensile strength of the pelvic peritoneum. We have indicated that, after a certain number of days, disruption no longer occurred in the wound but in the pelvic peritoneum. As soon as this point was reached the tensile strength of the wound was no longer measurable. It is obvious that

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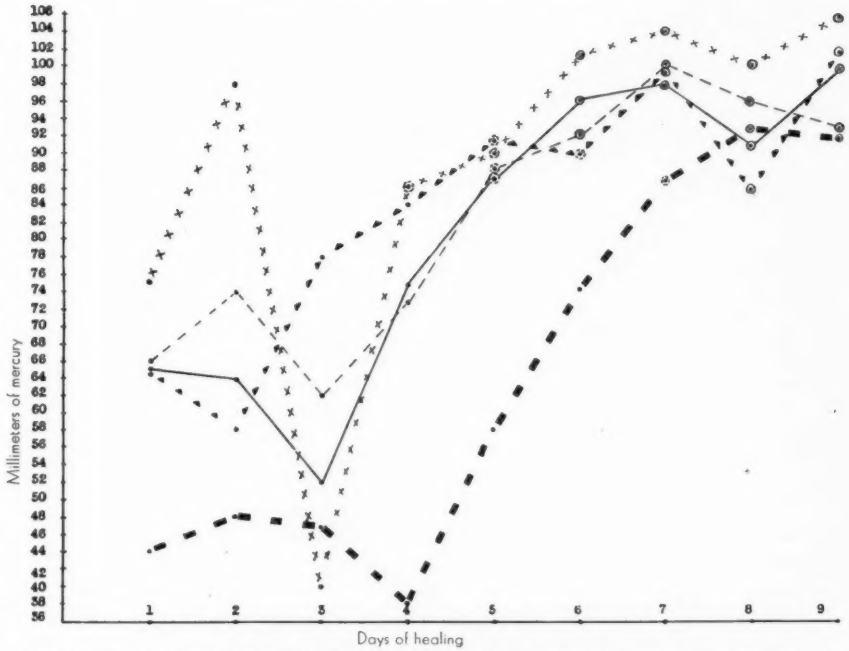
Parts I and II are to appear in later issues of International Abstract of Surgery; Part III, appears in SURGERY, GYNECOLOGY AND OBSTETRICS, 1943, 77: 243–249.

[1] HOWES, E. L., and HARVEY, S. C. Ann. Surg., 1935, 102: 941.

[2] Graphs 1 to 5 appear in Part III.



Graph 6. Tensile strength of wounds sutured with catgut (solid rectangles), cotton (broken line), wire (solid line), silk (crossed line), and nylon (triangular line). The dot within circle indicates no further disruption in wounds; dot within dotted circle indicates some wounds that disrupted, and the heavy dots indicate that all wounds disrupted.

all tensile strength data recorded for those animals in which disruption did not occur in the wound actually represent the tensile strength of the pelvic peritoneum. Wound strength is this figure, plus an unknown. Averages of these data have been taken to show additional points on the curve of healing.

In wounds sutured with silk, wire, or cotton, no disruptions were observed after the 5th day; in nylon sutured wounds, after the 6th day; and in catgut sutured wounds after the 9th day. However, among silk sutured wounds 4 of 5 disrupted on the 4th day and only 1 of 5 on the 5th day. Some cotton and some wire sutured wounds did not disrupt on the 5th day, and some nylon sutured wounds did not disrupt on the 5th and 6th days.

A further comparison of wound disruptions in relation to suture material may be made by an examination of Chart 2[1] and Table IX.

[1]Chart 1 appears in Part II—International Abstract of Surgery, December, 1943.

In interpreting these data presented in Chart 2 it must be kept in mind that a period longer than the lag period is covered. As may be noted in Tables IV-A, V-A, VI-A, VII-A, and VIII-A, disruptions occurred in the wounds after the end of the lag period.

The significant finding here is the relationship of suture material to the number of disrupted wounds. Catgut sutured wounds showed the highest percentage of disruptions, with cotton next. Silk sutured wounds showed the lowest percentage of disruptions. Disruption occurred in a catgut sutured wound on the 9th day, 3 days after the last disruption in a nylon sutured wound and 4 days after the last disruption in silk, wire, and cotton sutured wounds.

Catgut sutured wounds clearly had the longest lag period, even though previously we have made mention of the fact that possibly cotton sutured wounds also had a lag period of 4 days. We also mentioned the fact that the pattern

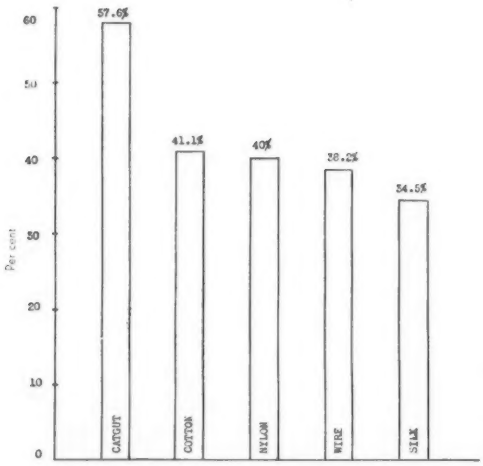


Chart 2. [1]Percentage of wound disruptions.

of healing of cotton sutured wounds with respect to tensile strength was entirely different from that of wounds sutured with any of the other materials. The fact that cotton had the second highest percentage of wound disruptions seems to lend emphasis to our previous statement that possibly the lag period of cotton sutured wounds was the same length as that of catgut sutured wounds.

Tables X, XI, XII, XIII, and XIV present the results of a day by day analysis of differences in mean tensile strength of wounds during and directly following the lag period.

In assembling these data, care had to be taken in computing the mean tensile strengths in order to be certain that values for wound disruptions only were included. As the days passed, wound disruptions became fewer and fewer, regardless of the type of suture material used, so that by the 5th day there were not sufficient data available to make possible tests for significance of differences in mean tensile strength.

[1]Chart 1 appears in Part II, Internat. Abstract Surg., December, 1943.

TABLE IX.—WOUND DISRUPTIONS IN PERCENTAGE OF TOTAL DISRUPTIONS

Suture material	Total number of disruptions*	Total number of wound disruptions	Wound disruptions per cent
Catgut	66	41	61.2
Cotton	56	23	42.9
Nylon	55	22	40.0
Wire	55	21	38.2
Silk	56	21	37.5

*Equal to number of animals tested.

Before we attempt to draw any conclusions from our results, a word to the method of reading these tables may not be amiss.

Let us consider Table X, which is typical. Ten tests are presented. The first column indicates that we are testing the mean pressure necessary to cause disruption in catgut sutured wounds on the 1st postoperative day against the mean pressure necessary to cause disruption in silk sutured wounds on the 1st postoperative day; catgut against wire, catgut against cotton, catgut against nylon, and so on.

On the 1st postoperative day, the mean tensile strength of wounds sutured with any of the nonabsorbable materials was significantly greater than the mean tensile strength of wounds sutured with catgut. Furthermore, among the nonabsorbable sutured wounds, although differences in mean tensile strength were observed, in no case were these differences significant.

On the 2d postoperative day (Table XI) only nylon sutured wounds showed a mean tensile strength not significantly greater than that of catgut sutured wounds. On this day the experiments showed that the mean tensile strength of silk sutured wounds was significantly greater than that of wounds sutured with any of the other nonabsorbable materials, and there were no significant differences in mean tensile strength among wounds sutured with wire, cotton, or nylon.

On the 3d postoperative day, there were some reversals in the relationship of tensile strengths (see Table XII). Whereas on the 2d day the mean tensile strength of silk, wire, or cotton sutured wounds was significantly greater than that of catgut sutured wounds, and the mean tensile strength of nylon sutured wounds was not significantly greater than that of catgut sutured wounds, the 3d day showed the mean tensile strength of nylon sutured wounds to be significantly greater than that of catgut sutured wounds, while the mean tensile strength of wounds sutured with the other nonabsorbable materials was not significantly

TABLE IV-A.—DATA ON WOUNDS SUTURED WITH CATGUT—NO. 0000 PLAIN, AND NO. 0000 CHROMIC

Days post-operative	Number of animals tested / Suture material	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	6 Plain	43	44	Wound	None taken
	Plain	44		Wound	Negative
	Plain	44		Wound	Negative
	Chromic	44		Wound	Negative
	Chromic	44		Wound	Staphylococcus aureus
	Chromic	46		Wound	Negative
2	6 Plain	49	47	Wound	Nonhemolytic streptococcus
	Plain	49		Wound	Negative
	Plain	51		Wound	Negative
	Chromic	44		Wound	Negative
	Chromic	48		Wound	None taken
	Chromic	44		Wound	None taken
3	6 Plain	24	47	Wound	Negative
	Plain	50		Wound	Negative
	Plain	63		Wound	Negative
	Chromic	42		Wound	Negative
	Chromic	55		Wound	Negative
	Chromic	46		Wound	Negative
4	7 Plain	34	38	Wound	None taken
	Plain	28		Wound	None taken
	Plain	45		Wound	Negative
	Plain	33		Wound	Pyogenic Staphylococcus aureus
	Chromic	33		Wound	Negative
	Chromic	57		Wound	Negative
	Chromic	35		Wound	Nonhemolytic streptococcus
5	6 Plain	144		Wound	None taken
	Plain	64		Wound	Staphylococcus aureus
	Plain	66		Wound	Negative
	Chromic	61		Wound	Negative
	Chromic	59		Wound	Negative
	Chromic	55		Wound	Negative
6	6 Plain	66	75	Wound	Negative
	Plain	61		Wound	Negative
	Plain	98		Wound	Negative
6	Chromic	82	75	Wound	Negative
	Chromic	68		Wound	Nonhemolytic streptococcus
	Chromic	74		Wound	Negative
7	6 Plain	92	87	Pelvis	Nonhemolytic streptococcus and Staphylococcus aureus
	Plain	87		Wound	Negative
	Plain	87		Wound	Nonhemolytic streptococcus
	Chromic	85		Iliac	Negative
	Chromic	86		Wound	Green staphylococcus
	Chromic	86		Pelvis	Negative
8	6 Plain	83	93	Iliac	Negative
	Plain	85		Iliac	Negative
	Plain	85		Iliac	Negative
	Chromic	99		Pelvis	Staphylococcus aureus
	Chromic	107		Pelvis	Negative
	Chromic	96		Pelvis	Negative
9	Plain	89	92	Wound	Negative
	Plain	86		Pelvis	Negative
	Plain	93		Pelvis	Negative
	Chromic	91		Pelvis	Colon bacillus
	Chromic	111		Pelvis	Negative
	Chromic	82		Iliac	Negative
13	3 Plain	99	97	Pelvis	Negative
	Plain	105		Pelvis	Nonhemolytic streptococcus
	Chromic	86		Pelvis	Negative
21	2 Plain	80	88	Iliac	Negative
	Chromic	96		Pelvis	Negative
31	2 Plain	103	106	Pelvis	Negative
	Chromic	110		Pelvis	Negative
45	2 Plain	97	98	Pelvis	Negative
	Plain	100		Pelvis	Negative
62	2 Plain	100	99	Pelvis	Negative
	Chromic	98		Pelvis	Negative

TABLE V-A.—DATA ON WOUNDS SUTURED WITH SILK—B(DEKNATEL)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	5	63	77	Wound	Negative
		79		Wound	Negative
		79		Wound	Negative
		82		Wound	Negative
		82		Wound	Negative
2	5	101	98	Wound	Negative
		116		Wound	Negative
		90		Wound	Negative
		93		Wound	Negative
		91		Wound	Negative
3	6	40	40	Wound	Negative
		42		Wound	Negative
		40		Wound	Negative
		41		Wound	Negative
		40		Wound	Staphylococcus aureus
		40		Wound	Negative
4	5	76	86	Wound	Negative
		84		Wound	Negative
		83		Wound	Negative
		101		Pelvis	Negative
		84		Wound	Negative
5	5	81	88	Iliac	Nonhemolytic streptococcus
		96		Pelvis	Negative
		83		Wound	Negative
		95		Pelvis	Negative
		84		Iliac	Negative
6	5	101	99	Pelvis	Negative
		101		Pelvis	Negative
6	5	93	99	Pelvis	Negative
		101		Pelvis	Negative
		101		Pelvis	Negative
7	5	106	104	Pelvis	Negative
		97		Pelvis	Negative
		111		Pelvis	Negative
		107		Pelvis	Negative
		100		Pelvis	Negative
8	5	93	100	Pelvis	Negative
		121		Pelvis	Negative
		96		Pelvis	Negative
		96		Pelvis	Staphylococcus aureus
		95		Pelvis	Negative
9	5	100	105	Pelvis	Negative
		102		Pelvis	Negative
		118		Pelvis	Negative
		103		Pelvis	Negative
		103		Pelvis	Negative
13	2	100	100	Pelvis	Negative
		100		Pelvis	Negative
21	2	105	105	Pelvis	Negative
		105		Pelvis	Staphylococcus aureus
31	2	104	104	Pelvis	Negative
		104		Pelvis	Negative
45	2	101	100	Pelvis	Negative
		101		Pelvis	Negative
62	2	115	107	Pelvis	Negative
		100		Pelvis	Negative

greater than that of catgut sutured wounds. On this day (as on the 2d postoperative day) the mean tensile strength of silk sutured wounds was significantly greater than that of wounds sutured with wire, cotton, or nylon.

On the 3d postoperative day, there was no significant difference in mean tensile strength between wire sutured wounds and cotton sutured wounds, but the mean tensile strength of nylon sutured wounds was significantly greater than that of wire or cotton sutured wounds.

On the 4th postoperative day, the picture was the same as on the 1st day (see Table XIII).

On the 5th postoperative day, it was impossible to make tests of significance in mean tensile strength except in the case of catgut-cotton, because by this day so few wounds sutured with nonabsorbable materials were disrupting. All catgut sutured wounds on this day, however, disrupted. In the catgut-cotton test it was demonstrated that, as on the 4th day, the mean tensile strength of cotton su-

TABLE VI-A.—DATA ON WOUNDS SUTURED WITH COTTON—NO. 000 (GUEDEBROD)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	5	67	64	Wound	None taken
		67		Wound	Negative
		66		Wound	Negative
		60		Wound	Negative
		60		Wound	Negative
2	5	71	74	Wound	None taken
		71		Wound	None taken
		71		Wound	None taken
		80		Wound	Negative
		77		Wound	Negative
3	5	61	60	Wound	Negative
		59		Wound	None taken
		61		Wound	None taken
		61		Wound	Nonhemolytic streptococcus
		60		Wound	None taken
4	5	70	71	Wound	None taken
		84		Wound	None taken
		65		Wound	Negative
		67		Wound	Negative
		69		Wound	None taken
5	5	81	87	Wound	Negative
		89		Wound	Negative
		88		Wound	Negative
		90		Pelvis	Negative
		88		Pelvis	Negative
6	5	88	92	Pelvis	Negative
		87		Pelvis	Negative
		94		Pelvis	Negative
6	5	103	92	Pelvis	Negative
		89		Pelvis	Negative
7	5	111	100	Pelvis	None taken
		87		Pelvis	Negative
		97		Pelvis	Negative
		106		Pelvis	Negative
		100		Pelvis	Negative
8	5	95	101	Pelvis	Negative
		111		Pelvis	Negative
		85		Pelvis	Negative
		121		Pelvis	Negative
		95		Pelvis	Streptococcus (alpha type)
9	5	92	93	Pelvis	Negative
		90		Pelvis	Negative
		90		Pelvis	Negative
		104		Pelvis	Negative
		87		Pelvis	None taken
13	2	95	95	Pelvis	Negative
		95		Pelvis	Negative
21	2	105	104	Pelvis	Negative
		103		Pelvis	Negative
31	2	100	102	Pelvis	Negative
		105		Pelvis	Negative
45	2	101	101	Pelvis	Negative
		101		Pelvis	Negative
62	3	106	103	Pelvis	Negative
		98		Pelvis	Negative
		105		Pelvis	None taken

tured wounds was significantly greater than that of wounds sutured with catgut (Table XIV).

The data presented in Tables X, XI, XII, XIII and XIV are summarized in Table XV.

On the 1st and 2d postoperative days the mean tensile strength of catgut sutured wounds was significantly less than the mean tensile strength of silk sutured wounds. On the 3d day the mean tensile strength of catgut sutured wounds was not significantly greater than the mean tensile strength of silk sutured wounds. On the 4th day the relationship was the same as on the 1st and 2d days and on the 5th day there were not sufficient data to make a test possible.

The group of tests shows that during the lag period the mean tensile strength of catgut sutured wounds was always less than that of wounds sutured with any of the other materials, except on the 3d day, when the mean tensile strength of silk sutured wounds dropped to a level of less, but not significantly less than that of catgut.

The remaining tests concern the nonabsorbable sutures. It will be seen that in general

TABLE VII-A.—DATA ON WOUNDS SUTURED WITH WIRE—No. 36 STAINLESS STEEL ALLOY (PILLINGS)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	5	67	65	Wound	Negative
		67		Wound	Negative
		65		Wound	Negative
		65		Wound	Negative
		61		Wound	Negative
2	5	70	64	Wound	Negative
		65		Wound	Negative
		70		Wound	Negative
		53		Wound	Negative
		63		Wound	Staphylococcus aureus
3	5	53	52	Wound	Negative
		50		Wound	Nonhemolytic streptococcus
		53		Wound	Staphylococcus aureus
		50		Wound	Negative
		53		Wound	Negative
4	5	71	75	Wound	Negative
		70		Wound	Negative
		77		Wound	Negative
		76		Wound	Negative
		79		Wound	Negative
5	5	85	87	Wound	Negative
		94		Pelvis	Negative
		85		Iliac	Negative
		85		Scrotum	Negative
		85		Iliac	Negative
6	5	114	96	Pelvis	Negative
		97		Pelvis	Negative
6	5	95	96	Pelvis	Negative
		87		Pelvis	Negative
		87		Pelvis	Negative
7	5	110	98	Pelvis	Negative
		87		Pelvis	Negative
		98		Pelvis	Negative
		98		Pelvis	Negative
		96		Pelvis	Negative
8	5	101	91	Pelvis	Negative
		90		Pelvis	Negative
		88		Pelvis	Negative
		88		Pelvis	Negative
		88		Pelvis	Negative
9	5	96	100	Pelvis	Nonhemolytic streptococcus
		103		Pelvis	None taken
		100		Pelvis	None taken
		100		Pelvis	None taken
		100		Pelvis	None taken
13	2	88	88	Iliac	Negative
		88		Iliac	Negative
21	2	82	82	Iliac	Negative
		83		Iliac	Negative
31	2	110	106	Pelvis	Negative
		103		Pelvis	Negative
45	2	101	100	Pelvis	Negative
		100		Iliac	Negative
62	2	110	105	Pelvis	Negative
		100		Pelvis	Negative

there were no significant differences in mean tensile strength of wounds sutured with these materials. However, in the tests of silk against the other nonabsorbable sutures, on the 2d and 3d postoperative days the mean pressures necessary to cause disruption in silk sutured wounds were significantly different from those necessary to cause disruption in wire, nylon, and cotton sutured wounds. On these days, as shown in Graph 6, the disruption pressures for silk sutured wounds varied far more widely than did the disruption pressures for any of the other materials. It should be noted also that the mean disruption pressure for silk sutured wounds was not significantly less than that for catgut sutured wounds on the 3d postoperative day, even with the great decrease in the pressure which is necessary to cause disruption in silk sutured wounds on that day.

From the results of these tests, we may conclude that the use of catgut results, first, in a longer lag period, and second, in weaker wounds during the lag period.

TABLE VIII-A.—DATA ON WOUNDS SUTURED WITH NYLON—B (DEKNATEL)

Days postoperative	Number of animals tested	Pressure—mm. mercury—necessary to cause disruption	Mean pressure necessary to cause disruption, mm. mercury	Site of disruption	Culture
1	5	47	65	Wound	Negative
		70		Wound	Negative
		71		Wound	Negative
		67		Wound	Negative
		68		Wound	Negative
2	5	55	58	Wound	Negative
		73		Wound	Negative
		69		Wound	Negative
		49		Wound	Negative
		46		Wound	Negative
3	5	66	79	Wound	Negative
		96		Wound	Negative
		69		Wound	Negative
		66		Wound	Negative
		97		Wound	Negative
4	5	106	84	Wound	Negative
		75		Wound	Negative
		82		Wound	Negative
		75		Wound	Negative
		80		Wound	Negative
5	5	105	93	Pelvis	Negative
		89		Wound	Negative
		91		Pelvis	Negative
		91		Pelvis	Negative
		88		Iliac	Negative
6	5	90	92	Iliac	Negative
		94		Iliac	Negative
		94		Iliac	Negative
6	5	80	92	Wound	Negative
		100		Pelvis	Negative
7	5	83	99	Iliac	Staphylococcus aureus
		103		Pelvis	Negative
		108		Pelvis	Negative
		100		Pelvis	Negative
		100		Pelvis	Negative
8	5	83	86	Iliac	Negative
		81		Iliac	Negative
		97		Iliac	Negative
		84		Iliac	Negative
		84		Iliac	Negative
9	5	103	101	Pelvis	Staphylococcus aureus
		100		Pelvis	Negative
		100		Pelvis	Staphylococcus aureus
		100		Pelvis	Negative
		102		Pelvis	Negative
13	2	102	103	Pelvis	Staphylococcus aureus
		105		Pelvis	Negative
21	2	110	105	Pelvis	Negative
		100		Pelvis	Negative
31	2	105	105	Pelvis	Negative
		105		Pelvis	Negative
45	2	111	108	Pelvis	Negative
		105		Pelvis	Negative
62	2	100	100	Pelvis	Negative
		100		Pelvis	Negative

The significant finding here is that there is no real basis for preferring one nonabsorbable suture over another—as far as tensile strength of wounds during the first 5 postoperative days is concerned. However, the use of any of these nonabsorbable sutures resulted in stronger wounds than were obtained with catgut.

From the data presented in Table XV we are able to make some further comments as to the length of the cotton lag period. On the 4th postoperative day, the "extra" day in the cotton lag period, the mean tensile strength of cotton sutured wounds was significantly greater than that of catgut sutured wounds. The important aspect is tensile strength rather than length of lag period, so that when comparing two suture materials, possibly with lag periods of equal length, one of which results in wounds with a greater tensile strength than does the other, it would appear that that material which more rapidly brings about an increase in tensile strength of the wound is preferable. Although these data do not enable us to deter-

TABLE X.—ANALYSIS OF TESTS PERFORMED 1ST DAY AFTER OPERATION TO ASCERTAIN WHETHER THE DIFFERENCES IN MEAN TENSILE STRENGTH NECESSARY TO DISRUPT WOUNDS ARE SIGNIFICANT

Test	Mean pressure, mm. mercury, necessary to cause disruption of wound					Number of animals tested					"t"	Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	44	77				6	5				10.1	9	3.3	S
Catgut wire	44		65			6		5			19.3	9	3.3	S
Catgut cotton	44			64		6			5		12.9	9	3.3	S
Catgut nylon	44				65	6				5	5.2	9	3.3	S
Silk wire		77	65				5	5			3.2	8	3.4	N.S.
Silk cotton		77		64			5		5		3.3	8	3.4	N.S.
Silk nylon		77			65		5			5	2.1	8	3.4	N.S.
Wire cotton			65	64				5	5		.5	8	3.4	N.S.
Wire nylon			65		65			5		5				No D.
Cotton nylon				64	65				5	5	.2	8	3.4	N.S.

S., Significant; N.S., not significant; N.D., no difference.
*The "critical" value of "t" is taken to be at the .01 level of significance. At this level a difference in mean pressure as great, or greater than that observed may be considered as due to chance, 1 time in 100.

mine definitely the length of the cotton lag period, they do enable us to evaluate the importance of this "peculiar" characteristic of cotton sutured wounds, namely, that their tensile strength is greater than that of catgut sutured wounds.

The next matter that comes up for consideration is a comparison of wound strengths during the postlag period.

From the 4th to the 7th day the mean pressures necessary to cause disruption in catgut sutured wounds were, on the average approximately 30 millimeters of mercury less than those necessary for disruption of wounds sutured with the nonabsorbable materials—or approximately one-third of the pressure necessary to disrupt the abdomens of healthy rats. Here we have further evidence that nonaborbable sutures are preferable to catgut. This statement is based upon the data presented in Table XVI and Graph 6. Table XVI is a summary of data on mean pressures which are

TABLE XI.—ANALYSIS OF TESTS PERFORMED 2D DAY AFTER OPERATION

Test	Mean pressure, mm. mercury, necessary to cause disruption of wound					Number of animals tested					"t"	Degrees of freedom	Value of "t" at critical level	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	47.5	98				6	5				11.2	9	3.3	S
Catgut wire	47.5		64			6		5			6.4	9	3.3	S
Catgut cotton	47.5			74		6			5		12.5	9	3.3	S
Catgut nylon	47.5				58	6				5	2.2	9	3.3	N.S.
Silk wire		98	64				5	5			5.9	8	3.4	S
Silk cotton		98		74			5		5		4.6	8	3.4	S
Silk nylon		98			58		5			5	5.5	8	3.4	S
Wire cotton			64	74				5	5		2.7	8	3.4	N.S.
Wire nylon			64		58			5		5	1.0	8	3.4	N.S.
Cotton nylon				74	58				5	5	2.8	8	3.4	N.S.

S., Significant; N.S., not significant.
*The "critical" value of "t" is taken to be at the .01 level of significance. At this level a difference in mean pressure as great, or greater than that observed, may be considered as due to chance, 1 time in 100.

TABLE XII.—ANALYSIS OF TESTS PERFORMED 3D DAY AFTER OPERATION

Test	Mean pressure, mm. mercury, necessary to cause disruption of wound					Number of animals tested					"t"	Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	47	40				6	6				1.3	10	3.2	N.S.
Catgut wire	47		52			6		5			.8	9	3.3	
Catgut cotton	47			60		6			5		2.2	9	3.3	N.S.
Catgut nylon	47				79	6				5	5.2	9	3.3	S
Silk wire		40	52				6	5			10.3	9	3.3	S
Silk cotton		40		60			6		5		40.8	9	3.3	S
Silk nylon		40			79		6			5	26.3	9	3.3	S
Wire cotton			52	60				5	5		1.0	8	3.4	N.S.
Wire nylon			52		79			5		5	15.3	8	3.4	S
Cotton nylon				60	79				5	5	11.6	8	3.4	S

S., Significant; N.S., not significant.
*The "critical" value of "t" is taken to be at the .01 level of significance. At this level a difference in mean pressure as great, or greater than that observed, may be considered as due to chance, 1 time in 100.

shown in Tables IV-A, V-A, VI-A, VII-A and VIII-A. The means presented in this table were obtained by av eraging all pressures necessary to cause disruption, regardless of the site of disruption. The Tables IV-A, V-A, VI-A, VII-A, and VIII-A indicate which of these means represent disruption in the wound only, which represent disruption in the wound and in other areas in the pelvic peritoneum, and which indicate disruption in the pelvic peritoneum only.

It was found that the average pressure necessary to cause disruption in the abdomen of the control rats was 98 millimeters ± 5.2 millimeters. This value may be regarded as the mean tensile strength of the abdomen of a healthy rat.

As time passed, it was observed that the pressure necessary to cause disruption in the abdomens of the experimental animals increased (see Table XVI). In fact, after a time, the mean pressure necessary to cause disruption attained a level at least as high as that found for the controls. At this stage the operative wounds had healed sufficiently so that the abdomens of these animals were

TABLE XIII.—ANALYSIS OF TESTS PERFORMED 4TH DAY AFTER OPERATION

Test	Mean pressure, mm. mercury, necessary to cause disruption of wound					Number of animals tested					"t"	Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	38	82				7	5				8.4	10	3.2	S
Catgut wire	38		75			7		5			7.9	10	3.2	S
Catgut cotton	38			71		7			5		6.3	10	3.2	S
Catgut nylon	38				84	7				5	7.0	10	3.2	S
Silk wire		82	75				5	5			3.2	8	3.4	N.S.
Silk cotton		82		71			5		5		3.1	8	3.4	N.S.
Silk nylon		82			84		5			5	.3	8	3.4	N.S.
Wire cotton			75	71				5	5		1.1	8	3.4	N.S.
Wire nylon			75		84			5		5	1.5	8	3.4	N.S.
Cotton nylon				71	84				5	5	2.0	8	3.4	N.S.

S., Significant; N.S., not significant.
*The "critical" value of "t" is taken to be at the .01 level of significance. At this level a difference in mean pressure as great, or greater than that observed, may be considered as due to chance, 1 time in 100.

TABLE XIV.—ANALYSIS OF TESTS PERFORMED 5TH DAY AFTER OPERATION

Test	Mean pressure, in mm. mercury, necessary to cause disruption of wound					Number of animals tested					"t"	Degrees of freedom	Value of "t" at critical level*	Remarks
	Catgut	Silk	Wire	Cotton	Nylon	Catgut	Silk	Wire	Cotton	Nylon				
Catgut silk	58	83				6	1							N.S.D.
Catgut wire	58		85			6		1						S
Catgut cotton	58			86		6			3		5.5	7	3.5	S
Catgut nylon	58				89	6				1				N.S.D.
Silk wire		83	85				1	1						N.S.D.
Silk cotton		83		86			1		3					N.S.D.
Silk nylon		83			89		1			1				N.S.D.
Wire cotton			85	86				1	3					N.S.D.
Wire nylon			85		89			1		1				N.S.D.
Cotton nylon				86	89				3	1				N.S.D.

S., Significant; N.S., not significant; N.S.D., not sufficient data to test differences in means.
*Since there are so few observations, there is not sufficient information on which to base a statistical test. The best that can be done in interpretation of these results is to say that a difference is indicated by the experimental figures.

comparable in strength to the abdomens of healthy rats. At this point the abdomen of an experimental rat may be considered to be "normal" with respect to tensile strength. The fact that an abdomen is able to withstand a pressure as great as that which the abdomen of a healthy animal can stand before disrupting does not necessarily imply, from a clinical point of view, that the wound has healed, but it has improved sufficiently so that it no longer constitutes a weak area in the abdominal wall. When the mean pressure necessary to cause disruption in the abdomens of experimental rats is no longer significantly less than the mean pressure necessary to cause disruption in the abdomens of the control rats, or when this mean pressure is equal to, or greater than, the mean pressure necessary to cause disruption in the abdomen of the healthy animals, then from the point of view of tensile strength, the wounds may be considered to be healed.

TABLE XV.—SUMMARY OF ANALYSIS OF SIGNIFICANCE OF DIFFERENCES IN MEAN STRENGTH NECESSARY TO CAUSE WOUND DISRUPTION DURING AND DIRECTLY FOLLOWING THE LAG PERIOD.

Test	Days after operation				
	1	2	3	4	5
Catgut silk	S.L.	S.L.	N.S.G.	S.L.	N.S.D.
Catgut wire	S.L.	S.L.	N.S.L.	S.L.	N.S.D.
Catgut cotton	S.L.	S L.	N.S.L.	S.L.	S.L.
Catgut nylon	S.L.	N.S.L.	S.L.	S.L.	N.S.D.
Silk wire	N.S.G.	S.G.	S.L.	N.S.G.	N.S.D.
Silk cotton	N.S.G.	S.G.	S.L.	N.S.G.	N.S.D.
Silk nylon	N.S.G.	S.G.	S.L.	N.S.L.	N.S.D.
Wire silk	N.S.L.	S.L.	S.G.	N.S.L.	N.S.D.
Wire cotton	N.S.G.	N.S.L.	N.S.L.	N.S.G.	N.S.D.
Wire nylon	No diff.	N.S.G.	S.L.	N.S.L.	N.S.D.
Cotton silk	N.S.L.	S.L.	S.G.	N.S.L.	N.S.D.
Cotton wire	N.S.L.	N.S.G.	N.S.G.	N.S.L.	N.S.D.
Cotton nylon	N.S.L.	N.S.G.	S.L.	N.S.L.	N.S.D.
Nylon silk	N.S.L.	S.L.	S.G.	N.S.G.	N.S.D.
Nylon cotton	N.S.G.	N.S.L.	S.G.	N.S.G.	N.S.D.
Nylon wire	No diff.	N.S.L.	S.G.	N.S.G.	N.S.D.

S.L., significantly less; N.S.L., not significantly less; S.G., significantly greater; N.S.G., not significantly greater; N.S.D., not sufficient data to test differences in means.

Table XVII presents an analysis of differences between mean pressures necessary to cause disruption in the abdomens of experimental rats and mean pressures necessary to cause disruption in the abdomens of healthy rats.

The mean pressure necessary to disrupt abdomens of experimental animals whose wounds were sutured with catgut was significantly less than the mean pressure necessary to disrupt the abdomens of the control rats up to the 8th postoperative day. A similar condition existed until the 4th day in silk and nylon and until the 5th day in wire and cotton.

TABLE XVI.—MEAN PRESSURE (MM. MERCURY) NECESSARY TO CAUSE DISRUPTION IN ABDOMENS OF EXPERIMENTAL ANIMALS, REGARDLESS OF SITE OF DISRUPTION

Suture material	Days after operation													
	1	2	3	4	5	6	7	8	9	13	21	31	45	62
Catgut	44	47	47	38	58	75	87	93	92	97	88	107	99	99
Silk	77	98	40	86	88	99	104	100	105	100	105	104	101	108
Wire	65	64	52	75	87	96	98	91	100	88	83	107	101	105
Cotton	64	74	60	71	87	92	100	101	93	95	104	103	101	103
Nylon	65	58	79	84	93	92	99	86	101	104	105	105	108	100

This means that the period of "healing" with respect to tensile strength is prolonged when catgut is used, in comparison with the same period for silk, wire, cotton, and nylon sutured wounds. This period is 2 days longer than the wire and cotton "healing" periods and 3 days longer than the silk and nylon "healing" periods. It is evident that a nonabsorbable suture, with respect to "healing" from the point of view of tensile strength, is preferable to catgut. Among the nonabsorbable sutures the differences in the length of the

TABLE XVII.—SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN PRESSURES NECESSARY TO DISRUPT ABDOMENS OF EXPERIMENTAL RATS AND OF CONTROL RATS*

Suture material	Days after operation	Mean pressure mm. mercury (experimental)	Difference between experimental mean and control mean mm. mercury†	Number of animals	"t"	"n"	Value of "t" at critical level‡	Remarks
Catgut	1	44	54	6	16.7	24	2.80	S.L.
	2	47	51	6	15.5	24	2.80	S.L.
	3	47	51	6	11.9	24	2.80	S.L.
	4	38	60	7	16.3	25	2.80	S.L.
	5	58	40	6	11.0	24	2.80	S.L.
	6	75	23	6	5.4	24	2.80	S.L.
	7	87	11	6	3.4	24	2.80	S.L.
	8	93	5	6	1.3	24	2.80	N.S.L.
	9	92	6	6	1.5	24	2.80	N.S.L.
	13	97	1	3	.2	21	2.83	N.S.L.
	21	88	10	2	1.7	20	2.84	N.S.L.
Silk	1	77	21	5	5.4	23	2.81	S.L
	3	40	58	6	17.9	24	2.80	S.L.
	4	86	12	5	2.97	23	2.81	S.L.
	5	88	10	5	2.6	23	2.81	N.S.L.
Wire	1	65	33	5	9.2	23	2.81	S.L.
	2	64	34	5	8.9	23	2.81	S.L.
	3	52	46	5	12.9	23	2.81	S.L.
	4	75	23	5	6.3	23	2.81	S.L.
	5	87	11	5	3.01	23	2.81	S.L.
Wire (Continued)	6	96	2	5	.5	23	2.81	N.S.L.
	8	91	7	5	1.9	23	2.81	N.S.L.
	13	88	10	2	1.8	20	2.84	N.S.L.
	21	82	16	2	2.83	20	2.84	N.S.L.
Cotton	1	64	34	5	9.1	23	2.81	S.L.
	2	74	24	5	6.6	23	2.81	S.L.
	3	60	38	5	10.7	23	2.81	S.L.
	4	71	27	5	6.96	23	2.81	S.L.
	5	87	11	5	3.0	23	2.81	S.L.
	6	92	6	5	1.6	23	2.81	N.S.L.
	9	93	5	5	1.0	23	2.81	N.S.L.
	13	95	3	2	.5	20	2.84	N.S.L.
Nylon	1	65	33	5	8.0	23	2.81	S.L.
	2	58	40	5	9.2	23	2.81	S.L.
	3	79	19	5	5.2	23	2.81	S.L.
	4	84	14	5	3.1	23	2.81	S.L.
	5	93	5	5	1.3	23	2.81	N.S.L.
	6	92	6	5	1.6	23	2.81	N.S.L.
	8	86	12	5	3.3	23	2.81	S.L.

*Experimental mean pressures which are greater than control mean pressures were not tested.
†Control mean is equal to 98 mm. of mercury. There were 20 rats in control group.
‡The critical level is taken at the point where the probability is .01.

TABLE XVIII.—LATENT AND "HEALING" PERIODS OBSERVED IN RATS SUTURED WITH VARIOUS MATERIALS

Suture material	Length of latent period (days)	Length of "healing" period (days)
Catgut	4	7
Silk	3	4
Wire	3	5
Cotton	4*	5
Nylon	2	4

*The length of the cotton latent period is subject to two interpretations. As explained in the text, it may be considered as 3 or 4 days.

"healing" period were not great enough so that one material should be preferred over another. Between silk and nylon there was no difference nor was there any difference between wire and cotton, but between the former and latter groups there was a difference of 1 day in the length of the "healing" period.

An interesting relationship exists between the length of the lag period in increase in tensile strength and the length of the "healing" period just discussed. Table XVIII shows the lengths of these two periods in days for the 5 different suture materials used.

The interpretation of this relationship, which may be expressed in terms of the correlation coefficient, r, depends upon our interpretation of the length of the lag period in increase in tensile strength of cotton sutured wounds. As mentioned previously, the length of the cotton lag period could not be clearly determined. According to the interpretation this period could have been 3 days long or 4 days long.

The correlation between the length of the lag period and the length of the "healing" period was: (a) .7319 if the length of the cotton lag period is taken as 4 days; and, (b) .8660 if the period is taken to be 3 days.[1]

We may consider that the length of the "healing" period is dependent upon the length of the lag period. (It is impossible for the length of the lag period to be dependent upon the length of the "healing" period.) The longer the lag period the longer the period until the mean tensile strength of the abdomens of experimental rats is no longer significantly less than the mean tensile strength of abdomens of control rats. Therefore, we have another reason for regarding catgut in an unfavorable light. Catgut sutured wounds clearly had the longest lag period in increase in tensile strength and also the longest "healing" period with respect to tensile strength.

The results of our experiments lead us to the conclusion that the nonabsorbable sutures are superior to the absorbable suture with respect to tensile strength and that, in this same respect, one nonabsorbable suture is not to be preferred over another. This conclusion is based upon the following observations:

1. The lag period—that is, the period of delay in increase in tensile strength—was clearly the longest when catgut was the suture material used. The mean tensile strength of wounds sutured with this material was generally significantly less than that of wounds sutured with a nonabsorbable suture.

2. The use of catgut resulted in a greater total number of wound disruptions over the entire period of increase in tensile strength than was the case when the nonabsorbable sutures were used.

3. When a nonabsorbable suture was used the mean tensile strength of the abdomens of the experimental animals reached a level not significantly less than that of the control animals (that is, they became normal with respect to tensile strength) at an earlier date than was the case with catgut.

4. We found a high correlation between the length of the lag period in increase in tensile strength and the "healing" period with respect to tensile strength. The length of the "healing" period is dependent upon the length of the lag period. The longer the lag period, the longer the "healing" period.

Finally, nonabsorbable sutures displayed no important differences among themselves with respect to the points considered.

[1]These coefficients were computed by the product-moment formula. See Applied General Statistics, Croxton and Cowden, Chapter 22.

REASONS WHY THE ORTHODOX IS BETTER THAN THE KENNY TREATMENT OF POLIOMYELITIS

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IN the lay press and on the radio the Kenny treatment of poliomyelitis is being hailed as the dawn of a new era in the treatment of this disease and the orthodox treatment has been grossly misrepresented. It is thus desirable that the orthodox treatment be given a fair hearing. In this paper the two methods are described and the reasons for preferring the orthodox treatment are given.

Proponents of the Kenny method claim that the orthodox treatment is wrong because the true symptoms of the disease have never been recognized until Miss Kenny discovered them (6) and consequently we could not treat the true disease because we had never seen it. These symptoms are muscle spasm, inco-ordination, and mental alienation, and it is stated that these are Miss Kenny's contribution to the symptomatology of the disease. If we analyze these symptoms we find that they are not conditions which have not been recognized and treated by surgeons for a great many years, but they are new names for conditions that are well known to every surgeon who has to do with the treatment of patients with infantile paralysis. For instance, muscle spasm includes the conditions which we call tenderness, stiffness, and rigidity or early contracture of muscles, and we believe that they, with the pain, are caused by spinal and meningeal inflammation. Miss Kenny believes that a local condition (apparently an acute inflammation) is present in the muscle and that this is the cause of the spasm. There is no evidence that there is any disease in the muscle in poliomyelitis. We have treated this condition with uniform success by immobilization until the pain and tenderness subside.

Inco-ordination includes conditions which we have recognized and treated under two terms; one is mass movements and the other is trick movements or muscle substitution. We prefer to use the terms which we have used in the past, as they are more descriptive and because there is no true inco-ordination in the medical sense in infantile paralysis. We have treated this by muscle training.

The same is true of mental alienation. This includes muscles which are partially paralyzed and those which are temporarily paralyzed. There is nothing new about the recognition of this sympton, except the term "mental alienation," which we believe is not a good term for the condition present. We have treated this by muscle training.

It thus appears that Miss Kenny's new concept of the disease is not new at all and that her contribution to the symptomatology of the disease is the giving of new names to well known symptoms, all of which have been recognized and treated by orthodox methods.

In order that we may compare the two methods, it is first in order to describe very briefly the orthodox and the Kenny methods of treatment of the disease. The orthodox method will be given first. It has for its object the saving of life, maintenance of nutrition, relief of pain, protection of paralyzed muscles, maintenance of circulation, prevention of deformity, restoration of function and the rehabilitation of the patient.

The treatment is best described under the four recognized stages of the disease: the acute febrile stage, the stage of tenderness and early contracture, the convalescent stage, and the chronic stage.

The acute febrile stage. The acute febrile stage lasts but a few days. During this period paralysis appears and, as a rule, progresses rapidly until the disease subsides. The fever usually subsides within a day or two after the paralysis begins. In this stage we are dealing with a patient who is afflicted with an acute infectious disease. The treatment is largely medical, and the disease is self-limited. There is no specific treatment, and it is not possible

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to predict how extensive or how permanent the paralysis will be. However, we believe that, other things being equal, the less the patient is disturbed the better will be his resistance to the disease. Consequently, the patient is left severely alone and kept as quiet and as comfortable as possible. No exercises or physical therapeutic measures are prescribed during this period.

The stage of tenderness and early contracture. The stage of tenderness and early contracture begins when the fever has subsided—that is, within a day or two after the paralysis has appeared. During this stage the neck and spine are stiff and some of the muscles are tender and painful when stretched. There is a variable amount of pain in the extremities and the nonparalyzed tender muscles tend to contract and produce deformities and to stretch the muscles which have been paralyzed by the disease. Consequently, we keep the patient in bed and immobilize the paralyzed extremities in splints or casts in the physiological position. These splints or casts tend to relieve the pain and tenderness in the extremities and tend also to prevent deformities and the stretching of paralyzed muscles. They are not, as a rule, left on continuously, but are removed once or twice a day and the extremities are moved passively through whatever range of motion is possible without causing undue pain to the patient. This is done to keep the joints free and to prevent shortening of the muscles of the extremity.

Some orthopedic surgeons also use hot packs or warm baths during this stage for the relief of the pain, but these are not used routinely. It is also to be noted that the splints are used only in cases in which they are indicated to relieve pain and muscle tenderness, to prevent contracture, and to protect paralyzed muscles. The extremities which are not involved are not splinted. During this stage no massage or active movements of the paralyzed extremities are permitted, because it has been found that massage and active movement tend to prolong the tenderness and to increase the pain and contractures.

In paralyzed patients the period of tenderness and contracture usually lasts from 3 to 6 weeks, or longer, but rarely over 3 months under orthodox treatment. If the patient is not paralyzed and the tenderness is slight and there is no tendency to contracture, no splints are applied and no treatment is indicated, other than to permit the patient to convalesce from the acute febrile disease and then gradually resume his normal activities.

The convalescent stage. The convalescent stage begins when the stage of tenderness and contracture has passed, and it persists for from a few months to two years. During this period the paralyzed muscles tend to recover their powers spontaneously, unless the anterior horn cells in the spinal cord which supply them with their motor impulses have been killed by the disease. These muscles can be divided into three groups: (1) The motor nerve cells of the muscles are killed by the disease and the muscles are permanently paralyzed (2) The motor nerve cells of the muscles are not killed by the disease, but they are so severely injured that they are not able to function. These cells will recover and again send motor impulses to the muscles and the muscles will regain their power. And (3) some of the motor nerve cells which supply the muscles are killed and others are injured and will recover and again send motor impulses to the muscles and the muscles will regain part of their power, but will not become normal. The permanent loss of power in a given muscle will vary directly with the percentage of its motor cells which are killed.

Since it is not possible to differentiate the permanent from the temporarily and partially paralyzed muscles, except by noting the recovery of the latter two groups, all paralyzed muscles are treated by muscle training and this treatment is begun as soon as possible after the pain and tenderness have subsided. If the treatment is followed by reappearance of the pain and tenderness the muscles are again put at rest for a few days and then the treatment is resumed.

It is my belief that if deformities are prevented the residual paralysis in poliomyelitis is dependent upon the death of motor cells supplying the muscles and that most of the recovery from the disease is spontaneous and is not greatly influenced by treatment. This recovery from the temporary paralysis is not sudden, but occurs gradually as the patient's

pain and stiffness disappear, and he repeatedly attempts to use his extremities. It is thus evident that I believe that the chief value of muscle training is that deformities are prevented or corrected and the temporarily paralyzed muscles are protected from stretching and fatigue while they are regaining their power, and that the maximum power is developed in that portion of the partially paralyzed muscles which still retains a motor nerve supply.

In other words, in the spinal type of the disease there is no evidence that there is any permanent damage to the central nervous system other than the destruction of the motor cells. The anatomical damage to the nervous system is permanent, but the physiological damage is temporary and disappears spontaneously, and treatment may hasten, but is not responsible for, the recovery of function in anatomically intact neurones. It is because I hold this opinion that I have been misquoted as saying that "no treatment is any good."

Many orthopedic surgeons believe that connections between the cerebral cortex and the motor cells are damaged and that the central nervous system will not recover spontaneously, but that the patient can, by concentration on a given movement, either restore old pathways which would not be opened spontaneously or can actually develop new pathways to the muscles which perform the movement. For instance, Lovett (3) defined muscle training as "fundamentally an effort to restore a cerebral motor impulse to a muscle, an impulse which has been either impaired or lost during the acute stage of poliomyelitis" and states that it aims at "establishing a better co-ordination between the remaining nerve fibers supplying the affected muscle and second at securing contraction of the desired muscle, however feeble, which is of course the best possible treatment of the muscle itself."

However, regardless of our views we all use muscle training, but vary as to how much of the improvement we ascribe to the treatment and how much to the natural tendency of the muscles to recover their function.

The muscle training is begun shortly after the pain and tenderness have subsided. All immobilization is discontinued for a few days, and the patient is encouraged to exercise his extremities in order to loosen up the joints and muscles which may be temporarily stiffened from the immobilization. Usually he is put in a tub of water once or twice a day and exercises his limbs under water. After a few days the effects of the immobilization have disappeared and it is possible to perform a satisfactory muscle examination and determine the severity and distribution of the paralysis.

The treatment is so planned that muscles which are paralyzed are made to contract by the patient's attempt to perform movements which are accomplished by these muscles. If he is not able to perform the prescribed movement the physical therapist moves the part passively through the full arc of motion of the involved joint while the patient, by concentration, endeavors to perform the movement. As the muscles become stronger the assistance is discontinued and the patient performs the movement with gravity eliminated, against gravity, and against resistance. The number of times a given movement is repeated varies with the power present in the muscles, but care is taken not to fatigue them by excessive exercise, because it has been shown that overuse of a weak or partially paralyzed muscle tends to cause loss instead of gain in power.

Before beginning the active exercise the muscles are first warmed by radiant heat and massaged gently. In performing the prescribed exercises mass movements, trick movements, and muscle substitution are avoided and the patient is taught to relax the opposing muscles; in addition any muscles which have become shortened are stretched passively and actively. During this period the activity of the patient varies inversely with the extent of the paralysis. The paralyzed muscles are protected by braces or splints and he is gotten out of bed as soon as the surgeon judges that this can be done without damage to the weak muscles. The stiffness of the neck and spine nearly always disappears spontaneously and rarely requires special treatment.

The muscle training is best carried out by a physical therapist, but if one is not available an intelligent layman can be taught to carry

out the treatment in a fairly satisfactory manner. The muscles are tested every few weeks and not only is it noted whether or not a given muscle is able to contract, but its power is tested. The results of the muscle examinations are recorded and the progress of the patient can be determined by comparing the muscle chart with those made at previous examinations. When a given muscle approaches normal in power, treatment of this muscle is discontinued. The muscle training is continued until the patient is approximately normal or until repeated muscle examinations fail to show further improvement in spite of adequate treatment. When this occurs the convalescent stage is ended and the patient enters the chronic stage of the disease and whatever paralysis is still present is considered permanent.

The chronic stage. The chronic stage begins when the convalescent stage ends; that is, when there is no further hope of gain in power of the paralyzed muscles. Many partially paralyzed limbs contain muscles which are strong and which are opposed by weak muscles. In these limbs the muscle imbalance will tend to cause deformities over a period of years, and the same is true of the trunk. Some of these can be prevented by muscle transplantations or by stabilizing operations or by braces. The deformities which are most likely to occur are scoliosis, flexion deformities of the hips and flexion or hyperextension deformities of the knees and various deformities of the feet. In certain instances the patients are supplied with braces in order to enable them to use their paralyzed muscles more effectively. Likewise, orthodox treatment endeavors to improve the function of severely paralyzed limbs by surgery and to rehabilitate these patients in order that they may carry on a normal life.

The Kenny method. The treatment is begun in the acute febrile stage of the disease ("as soon as the diagnosis of infantile paralysis is made") and apparently hot packs are applied to the extremities and trunk of the patient from the beginning. These packs are kept up continuously for a period of 12 hours a day. During the other 12 hours the patient is permitted to rest. The packs are renewed on an average of once an hour, but in some instances they are renewed every 15 minutes and in others the intervals are lengthened to 2 hours. The object of the hot packs is to alleviate spasm of muscles; that is, the contracture of muscles which we believe is induced by the pain, tenderness, and hyperesthesia. It is also believed that they prevent or lessen the extent of the paralysis. The patient is kept flat in bed in the normal standing position with the feet supported by a board at the foot of the bed, similar to that used in the early orthodox treatment.

In addition to the hot packs the joints are moved daily, and the patient is taught to exercise his muscles and an attempt is made to re-educate the paralyzed muscles. This re-education is similar to the muscle training which is used in the orthodox method and has the same purpose in that it aims at the restoration of function in the paralyzed muscles. It differs in that it is begun in the acute stage of the disease and is continued through the stage of tenderness and contracture. It also differs in that no massage is used and attempts are made to stimulate individual muscles and the patient is made aware of the individual muscle that is to be exercised and taught its insertion and instructed to attempt to approximate the insertion to the origin of the muscle rather than to carry out a specific movement. I believe that the orthodox method is more natural and better because the brain pattern of muscle action is one of movement rather than one of action of a specific muscle.

The hot packs are continued as long as any muscle tenderness or any muscle spasm—that is, tightness or contracture of muscles—is present. Likewise, the rest in bed in the normal standing position is continued during this period. The same is true of the muscle re-education. The schedule is rigid and emphasis is laid on the point that the patient must get the full treatment as directed; otherwise, he is not receiving the Kenny treatment.

Muscle examination and tests of muscle power are prohibited. Likewise, no record is kept as to what muscles are paralyzed and what muscles are not paralyzed, although in some instances records are kept as to what muscles are spastic and tender. All muscles

which are not able to contract are considered alienated. Those which are able to contract, no matter how feebly, are, as nearly as I can determine, considered normal. If a muscle which is being re-educated shows any ability to contract or to develop power it is considered that the mental alienation is cured and this muscle is from then on considered normal.

In the Kenny treatment no account is taken of spontaneous recovery, but all recovery is attributed to the method. Braces are prohibited and it is even claimed that the board at the foot of the bed is not a brace to prevent equinus of the foot, but that it is put there to stimulate the normal standing reflex. These patients are not permitted to sit up or walk nor are they gotten out of bed until muscle spasm has disappeared. Consequently, the paralytic cases are maintained flat in bed in the normal standing position month after month and treated with hot packs and muscle re-education. Contractures and early deformities are prevented by constant attention and frequent manipulation and stretching of the contracted muscles which have been relaxed by the application of hot packs. The efforts of the therapists are principally directed at relaxing the spastic muscles, preventing incoordination and relieving mental alienation; that is, attempting to restore motor function to the paralyzed muscles.

The orthodox treatment is elastic and can be varied to suit the circumstances. What has been described is the standard orthodox treatment. The three principal variations are the under-water gymnasium of Lowman and the institute at Warm Springs, the prolonged protection of paralyzed muscles combined with intensive physical therapy, as practiced by the Kendalls in Baltimore, and what might be called the economical or common sense method.

It is this last which I use and which has proved to be satisfactory over a period of 15 years or more. The paralyzed limbs are immobilized during the stage of tenderness and contracture by splints which are removed daily for passive movements, or even by solid plaster casts in some instances. As soon as the tenderness and tendency to contracture have disappeared the casts or splints are removed, the patient is permitted to move around in bed, is put in a tub of warm water daily and instructed to exercise and loosen up the joints which may have been stiffened somewhat by the immobilization.

At the end of a week or so after the initial stiffness has disappeared a muscle examination is made and the extent of the paralysis is determined. Then a plan of treatment is decided upon, and a member of the patient's family or a physical therapist is instructed as to what muscles to exercise and the patient is permitted to resume his normal activities as rapidly as he is able to do so, care being taken to protect the paralyzed muscles from being stretched or fatigued. These are protected by braces or by plaster molds if necessary. This so called home treatment is continued until there is no further improvement, when the patient enters the chronic stage and surgery is performed if indicated, or, if necessary, braces are prescribed for future use. It is believed that by this method few muscles which would ever have regained a useful degree of power are sacrificed and much expensive and arduous treatment is avoided.

From what has been said here it is evident that the Kenny treatment is wrong in theory, because it is based on the belief that the principal lesion of the disease is spastic contracture which is due to an acute inflammatory process in the muscles. This is treated by the constant application of hot packs accompanied by attempts at muscle re-education which are begun in the acute stage of the disease. The orthodox treatment recognizes that the principal lesion of the disease is in the anterior horn cells of the spinal cord and that the principal cause of crippling (if deformities be prevented) is the permanent weakening or complete flaccid paralysis of muscles whose anterior horn cells have been partially or completely destroyed. It prevents deformities, protects paralyzed muscles, and restores the maximum degree of power to all of the muscles of the body which retain some nerve supply. The rigidity disappears during the period of immobilization and rarely needs any other treatment. It is believed that the orthodox treatment is superior to the Kenny treatment for the following reasons:

1. Constant application of hot fomentations and attempts at muscle re-education in the febrile stage of the disease will tend to aggravate, fatigue, and disturb a patient who is sick with an acute infectious disease which is self-limited, and any disturbance of such a patient may tend to weaken his resistance to the disease.

2. Refusal to use a respirator in the acute stage of the disease by the Kenny advocates may result in the death of certain patients with respiratory paralysis who could have been saved by a respirator.

3. There is no evidence that the Kenny treatment either prevents or decreases the extent of the paralysis.

4. Early active movement has been shown to prolong the stage of pain and contracture and tenderness in the muscles. Consequently, I believe that patients treated by the Kenny treatment tend to remain in this stage of the disease longer than would the same patients if treated by the orthodox method of immobilization of the paralyzed extremities accompanied by daily movement of the joints through the nonpainful range.

5. Kenny patients who are paralyzed are made to remain in bed in the normal standing position for months. This cannot but result in prolonging the stiffness of the spine and tightness of the hamstring and quadriceps muscles.

6. The Kenny method of maintaining the patients flat in bed in the normal standing position until the spasm disappears causes paralyzed patients to be much more completely immobilized and for a much longer time than the same patients would be if they were treated by the orthodox method.

7. Immobilization of a limb which is tender and painful in a well fitting splint or cast relieves the pain, relieves the tendency to muscle contracture, and prevents deformities much quicker and more easily than can be accomplished by the constant attention of a skilled therapist with the continuous application of hot packs for 12 hours a day. Those who deny this know little of the therapeutic value of rest.

8. Hot packs and warm baths are used by orthopedic surgeons occasionally for severe pain, but only for short periods and only during part of the day, and then for a definite reason and not as a routine or during the acute febrile stage of the disease.

9. Early deformities may be prevented by either the Kenny or the orthodox method, but I believe that they can be prevented more easily and effectively by orthodox treatment.

10. Late deformities due to muscle imbalance, especially scoliosis, calcaneous and flexion deformities of the hip, may occur under either method. The denial that these late deformities will occur in patients treated by the Kenny method is based upon wishful thinking rather than upon the observation over a period of years of patients who have survived with muscle imbalance. The Kenny method has no treatment for these late deformities. The orthodox method treats them by surgery or by braces.

11. Trick movements and mass movements (inco-ordination) are treated more effectively by the orthodox muscle training than by the Kenny method.

12. The Kenny method advocates recognize paralysis as occurring very rarely in the disease and consider paralyzed muscles as alienated until they have failed to respond to treatment.

13. The orthodox method advocates recognize temporary (mental alienation) and partial paralysis and treat the patient accordingly.

14. The advocates of the Kenny method ignore the power present in a muscle, but apparently believe that if a muscle can contract at all it is normal but merely partially alienated.

15. In the Kenny method muscle examination is forbidden and no records are kept of the condition of the muscles. Under orthodox treatment the muscles are examined regularly and the findings are recorded.

16. The principal effort of the Kenny treatment is directed toward relaxing the spastic muscles by very hot fomentations. Under orthodox treatment those muscles which are contracted are immobilized and prevented from shortening and tend to relax spontaneously as the pain and tenderness subside. It is for this reason that we have not emphasized this so called cardinal symptom which Miss Kenny claims to have discovered.

17. The very hot fomentations used in the Kenny method may cause burns and furuncles. I have seen both.

18. The orthodox method of muscle training is more natural and more effective than is the Kenny method of muscle re-education and in both systems the muscle training is directed at the relief of the same conditions, two of which Miss Kenny has renamed and claims to have discovered—mental alienation and inco-ordination.

19. The Kenny treatment does not protect paralyzed muscles from being stretched. Under orthodox treatment these muscles are protected with the hope that they may regain some of their power.

20. I have seen paralyzed patients under the Kenny treatment who were maintained in the so called normal standing position for periods of 6 months and more. In these patients there was marked stiffness of the back and hamstrings and quadriceps muscles were shortened. Under the orthodox treatment I believe that these same patients would have had less stiffness and no more paralysis, if as much.

21. In the Kenny treatment the patients are buoyed up by extravagant promises of complete cure. Many of these will have a rude awakening. Under orthodox treatment care is taken not to promise the patient more than can be expected.

22. Many Kenny patients will be handicapped by lack of splints which would enable more effective use of their paralyzed limbs.

23. All of the Kenny cures which I have seen were cures of nonparalytic patients who needed no treatment at all. There is no evidence that these patients were ever paralyzed and under orthodox methods no time or money would have been wasted in showering treatment upon them when they did not need it.

24. The advocates of the Kenny method do not recognize spontaneous recovery, but give credit to the method for all improvement which may occur in patients while under treatment and make extravagant claims of cures. The orthodox method advocates recognize that the disease is self-limited and that most of the improvement which occurs is spontaneous rather than the direct result of treatment.

25. The advocates of the orthodox method know that flaccid paralysis is the cause of crippling if deformity can be prevented. Consequently, the treatment of the paralyzed muscles is of first importance in the orthodox treatment while it plays a minor rôle in the Kenny method.

26. The Kenny method is expensive in material and man power; not only do the woolen blankets wear out after about a week's use and have to be replaced, but relatively large numbers of nurses and especially trained technicians are required to care for a given number of patients.

27. The Kenny method demands that the prescribed routine be carried out with exactness. It is very messy when many patients are present in a given hospital and requires special equipment and consequently it is not suitable in case of an epidemic. The orthodox treatment, on the other hand, is elastic and can be given anywhere. Poliomyelitis is an epidemic disease.

28. Kenny propaganda in the lay press and over the radio has misled the public by the repeated statements that the Kenny method cures 80 per cent of the patients while under orthodox treatment "the average percentage of recoveries was 12 per cent." I cannot but believe that this is a deliberate misstatement of facts, because, while no statistics have been published, the 80 per cent cures claimed for the Kenny method are apparently based on the treatment of every patient in a given locality who had infantile paralysis and these percentages are compared with those of Dr. McCarroll (5) who treated only patients who had residual paralysis of sufficient degree to cause them to come to the hospital for treatment; whereas, the large number of nonparalytic or temporarily paralyzed patients were not included in his statistics.

There were 3 recent epidemics on this continent in which the orthodox treatment was used: In Alberta in 1941 Dr. Huckell (2) states that 82.2 per cent of 167 patients recovered under orthodox treatment to a stage where they were normal or practically normal. Dr. H. Earle Conwell (1) states that 120 patients were personally followed by him in the Alabama epidemic in 1941 and that over

80 per cent of these 120 cases recovered under orthodox treatment to a degree where they were normal or practically normal. In the Baltimore epidemic of 1941 there were 296 cases of poliomyelitis. These were treated by the orthodox method and 9 died. Lenhard (4) examined the 289 survivors and found that 68 per cent of the patients had recovered and 14 per cent more had a slight residual paralysis, 11 per cent had moderate residual, 5 per cent had marked residual and only 2 per cent were wheel-chair patients.

It is thus evident that the Kenny method does not even claim to cure any higher percentage of patients than the orthodox method has been shown to cure in 3 recent epidemics.

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NOVOCAIN INJECTION FOR MINOR INJURIES IN THE MILITARY SERVICE

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"THE mission of the Medical Department is to preserve the fighting strength of the United States Army" (8). To attain this objective, the injured soldier must be returned to his post, physically fit for duty, in the shortest possible time. In noncombatant zones, minor traumatism is the commonest cause of disability. A problem not existing in civilian practice is that of hospitalization of the patient until he is fit for strenuous activity. The patient in civil life who would be allowed to recuperate while carrying on at least part of his work must be admitted to the hospital in military practice. This added hospitalization not only increases the burden on medical personnel but decreases the effectiveness of the patient's unit while he is absent. Therefore, any treatment which is consistent with excellent medical therapeutics, and at the same time results in a shorter period of disability, is highly desirable. With this in view, we have discarded the usual conservative treatment for minor injuries and have adopted the recently accepted method of novocainization of the injured part, as suggested by Leriche.

During the year 1942, it was necessary to admit to the hospital 55 patients with acute strain or sprain of the knee, ankle, or back. The average duration of hospitalization for these patients was 10.3 days. Since novocain injection has been used for these injuries, we have admitted only 1 patient with severe traumatic synovitis of the knee for 48 hours. Two patients with acute exacerbation of chronic low back strain have required hospitalization. In no other knee or back and no acute ankle injuries have patients needed admission. It should be noted that very severe injury, with complete ligamentous rupture requiring prolonged immobilization and other treatment, is not considered in this discussion.

This analysis is based on a series of novocain injections for 100 consecutive minor injuries seen at the Fort Myer Station Hospital during the past 5 months. Very minor strains and sprains are not included. In this series, ligamentous injury about the ankle joint was by far the most frequent, and the results of injection were most gratifying. Also included are injuries to the knee, shoulder, wrist, back, and miscellaneous injuries.

Novocain is a local anesthetic and as such its value is not questioned. William J. Mayo wrote "I do not look forward to the day when regional anesthesia will wholly displace general anesthesia; but undoubtedly it will reach and hold a very high position in surgical practice" (5). Today, 15 years later, we can also foresee this same drug reaching its heights as a therapeutic agent. This means the young surgeon should and must become expert in its use.

Novocain is the hydrochloride of para-aminobenzoyl-diethylaminoethanol. Labat states that the injection of this agent made in contact with a nerve, or in its proximate vicinity, results in a physicochemic combination with the nerve substance modifying its normal function and paralyzing the sensory nerve fibers. In the papers which we have reviewed, we have yet to find a satisfactory explanation for the mechanism which brings about the marked improvement in minor injuries following the injection of novocain. Based upon our observations of the symptoms and signs in these injuries, we believe the effect of novocain injection to be due to two principal factors; first, the immediate decrease of muscle spasm, and, second, the delayed but important correction of local anoxia.

In trauma, particularly in the region of a joint, the initial protective response is muscle

From the Surgical Service of the Station Hospital, Fort Myer, Virginia.

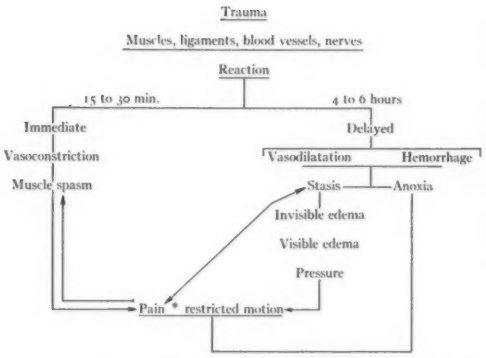

Chart 1. Diagram suggesting the pathologic physiology in injuries to muscles, ligaments, blood vessels and nerves.

spasm. This is demonstrated by the usual patient with a sprain of the ankle. The first symptoms are due primarily to restriction of joint motion rather than pain. At times, severe pain is not present until several hours after the injury. This may be explained by the following sequence. As stated, the first response is muscle spasm manifested by stiffness and decrease in motion. During this period, there is probably a transient vasoconstriction. As there is concomitant injury to the blood vessels and nerve fibers in the area, a vasodilatation then occurs. From the slowing of the blood stream in this area, the injury to the capillary walls, and the increased osmotic pressure (resulting from damaged tissue cells), first invisible edema and then obvious swelling of the part are noted.

With the clinically visible edema, there must also be swelling of the damaged nerve fibers, vessel walls, and muscular and ligamentous fibers. This edema, combined with the stasis of the blood stream, results in anoxia of the involved tissues. This combination of factors, i.e. the muscle spasm and anoxia, then results in a temporary vicious cycle, with the muscle spasm and anoxia bringing about further tissue damage, edema, and other untoward conditions.

To interrupt this cycle, two corrections must be made: the muscle spasm must be relaxed and the part must be adequately oxygenated. Novocain injected into the traumatized area performs these functions. By inhibiting the painful impulses, the immediate result is diminished muscle spasm with resultant increase in mobility of the part. With the action of the novocain on the blood vessels and nerve fibers, there is a return of normal vascular tonus bringing about improved circulation and better oxygenation. This improvement in the circulation and oxygenation plus the increased muscular activity leads to resorption of the edema fluid and extravasated blood, and a return to normal function.

TECHNIQUE

Before proceeding with the injection, all patients are examined clinically and roentgenologically. The patient is placed in the recumbent position as advised by Gorrell. This aids in preventing the occasional attack of syncope which occurred in about 10 per cent of our series. Although usually psychic in origin, the treatment itself is quite painful at times and this, no doubt, contributes to the side reaction. Pain appears to be most prominent when those areas which lie superficial as in the knee and wrist are injected. To allay apprehension the patient is reassured and the treatment is explained, with emphasis on the freedom from pain which will follow shortly. The most tender points in the injured area are then identified with finger pressure. The point or points are marked with gentian violet and the skin prepared with tincture of merthiolate or iodine. Sterility must be scrupulously maintained for the danger of infection is ever present. A wheal is then raised with 1 per cent novocain at the points marked with gentian violet. A 1½ inch 21 gauge needle is then introduced to the bone and a hematoma is searched for. If a hematoma can be found, and injected with the novocain, an excellent result may be expected. When no hematoma can be located, the area in general is infiltrated. Immediately after the injection, the area is lightly massaged to aid in diffusion. Active motion of the part is then insisted upon. At first the patient is hesitant, but as he appreciates his freedom from pain, he quickly co-operates. The result is a relaxation of the surrounding muscles, relief of pain, and a rapid return of normal function. If the joint involved is a weight bearing or carrying joint,

an adhesive strapping or tight muslin bandage is applied. This acts as a pressure bandage to encourage the resorption of edema fluid, and also to protect the joint from further injury, as emphasized by Frankel.

CASE REPORTS

CASE 1. Private S, while working on the garbage wagon, was thrown to the ground when the wagon swayed sharply. He landed on his right foot, severely twisting the right ankle. He was able to walk only with the greatest difficulty. Examination showed marked edema about the ankle with four plus tenderness over the anterior talofibular and deltoid ligaments. X-ray examination was negative for bone injury. A tight strapping was placed about the ankle, and he was returned to his quarters. The following day, he reported at the clinic, complaining of more severe pain and marked limp on walking. Examination was essentially as before. The tender points over the anterior talofibular and deltoid ligaments were each injected with 5 cubic centimeters of 1 per cent novocain, a hematoma being encountered in the talofibular area. A Gibney boot was applied. He obtained immediate and complete relief from pain and was able to walk bearing his full weight on the ankle. On the next day, there was no pain or limp on walking. Five days after the injection, he reported to the clinic, having been on full duty which involved much walking the previous day, and had no complaints. The strapping was removed and the patient was discharged.

CASE 2. Lt. N, while running, turned the right ankle. This was followed by difficulty in walking and increasing pain. He was seen that evening by the officer of the day, who strapped the ankle and ordered bed rest. Ten days later, he was seen in the clinic, still complaining of marked pain in the ankle. Examination showed swelling about the lateral malleolus with four plus tenderness over the anterior talofibular ligament. Pain was severe on inversion of the foot. X-ray examination was negative. Five cubic centimeters of 1 per cent novocain was injected into the tender area and a Gibney boot applied. The immediate result was excellent. Forty-eight hours later, the patient was still free from pain, limp, and tenderness. At the next visit, the following day, he stated that his ankle felt normal and that he had played baseball on the previous afternoon. The strapping was removed and he had no further difficulty.

CASE 3. Private K, while walking down hill during a training exercise, slipped and fell. The left leg slid backward, resulting in marked plantar flexion and inversion of the left foot. He complained of severe pain in the left ankle and could not bear weight. Examination showed four plus tenderness and marked edema over the lateral and anterior portion of the ankle. X-ray examination was negative. A needle was inserted down to the bone over the middle of the ankle, a hematoma was entered, and 5 cubic centimeters of blood was removed. Ten cubic centimeters of 1 per cent novocain was injected at this point and another 10 cubic centimeters into the talofibular ligament. The immediate result was relief of pain and marked increase in freedom of motion. The patient left the clinic walking without difficulty. He was followed for 10 days, and there was no recurrence of the pain or hemorrhage.

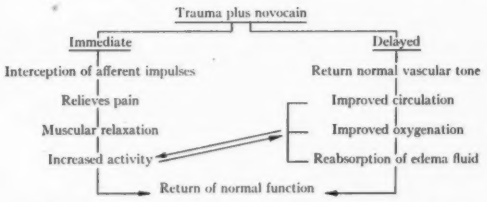

Chart 2. Diagram suggesting effect of novocain injection after injury, breaking vicious cycle by interception of afferent impulses.

We have injected 41 ankle sprains to date. Involved in these injuries are practically every ligament about the joint. The most frequently injured are the ligaments on the external side of the ankle. In some cases several ligaments were traumatized and each had to be infiltrated. Of the 41 cases, 31 involved the anterior talofibular ligament either alone or in combination with the calcaneofibular, deltoid, calcaneocuboid or anterior annular ligaments. Six cases involved the deltoid ligament, either alone or in combination with the lateral calcaneofibular, or posterior talotibial. The calcaneofibular ligament was injured alone in 2 cases; and the external talocalcaneal in 2 cases. The majority of these cases can be classed as severe sprains with edema, ecchymosis, and such pain as to cause from partial to complete incapacitation. Twenty-four of these sprains were classified as severe, 12 as moderately severe, and 5 as mild. In at least 50 per cent of the cases, a hematoma was encountered. In the early part of the series, this fact was not recorded as its significance was not recognized; therefore, a definite figure cannot be given. The amount of novocain injected varied from 3 to 20 cubic centimeters; the average amount was 10 cubic centimeters. A modified Gibney boot was applied in 28 cases, a muslin bandage in 3, and no support was used in 10. Our best results were obtained in cases in which patients were treated within

12 hours after injury, but good results were also noted in patients first seen 2 to 3 days following trauma and treatment with strapping and rest. The results in 73 per cent of the cases can be classified as excellent, with complete freedom from pain and full use of the ankle from the time of injection. Twenty-four per cent had slight residual soreness and stiffness for several days but not enough to prevent the performance of active duty. About 5 per cent of these patients required a second injection. Two per cent continued to have pain and must be classified as poor. In the 2 latter groups the probability is that all the involved areas were not injected at the first treatment, for usually on the patient's return, the tenderness was not found at the same point as that originally infiltrated. In the usual case, patient received only one treatment, the amount of novocain injected into each area being 6 to 8 cubic centimeters. We have had no cases which showed separation of the inferior tibiofibular joint as recently emphasized by Outland.

CASE 4. Private S, during a blackout, jumped from a truck and felt sudden severe pain in his left knee when it was sharply twisted. He walked with marked limp and had pain on flexion and extension of the joint. Examination showed four plus tenderness over the lateral ligament at its fibular insertion. X-ray examination was negative for bone injury. The knee was strapped and heat applied for 4 days with no improvement. Ten cubic centimeters of 1 per cent novocain was then injected into the tender area of the ligament with resultant immediate and permanent relief.

CASE 5. Private M stated he was drilling and while running at double time, he accidentally twisted his right knee. This was followed by pain which was aggravated by exercise. After 2 days, there was no improvement and he reported to the hospital for treatment. Examination showed limitation of motion and three plus tenderness over the medial collateral ligament at the insertion into the tibial condyle. There was no excess fluid in the joint and an x-ray film was negative for bone injury. Treatment consisted in the infiltration of 8 cubic centimeters of 1 per cent novocain into and about the tender area. The immediate result was loss of pain and increased mobility. Recovery was uneventful.

CASE 6. Corporal P fell in the kitchen while attempting to catch a platter of steaks and struck his left knee on the floor. He entered the clinic 4 hours later with severe pain and stiffness in the knee joint. Examination showed obliteration of the normal contour of the joint by increase of synovial fluid. No localized tender spot could be found, and there was no abnormal mobility of the joint. X-ray examination was negative for bone injury. Thirty cubic centimeters of viscid bloody fluid was aspirated from the joint and 10 cubic centimeters of 1 per cent novocain was injected. A pressure bandage was applied. He had no further pain and walked without difficulty. Two days later the bandage was removed and he was still able to walk without pain or limp. There was no reaccumulation of the excess joint fluid. Two weeks after injury joint appearance and function were normal.

Although injuries to the knee joint are not as frequent as those to the ankle in this clinic, we have used this treatment in 18 cases. The tibial collateral ligament was the site of the lesion in 11 cases, the fibular collateral ligament in 2, the quadriceps tendon in 3, and the patellar ligament in 1. There was 1 case of traumatic hemarthrosis thought to be due to synovial laceration. An average of 10 cubic centimeters of novocain was used in this group. Our results have been very encouraging although not as spectacular as in ankle injuries. This would be expected, as injuries of the knee are usually more serious than those of the ankle, due principally to the structural differences in the two joints. Knee injuries frequently need more than one injection. It is not uncommon to find sprains of the medial collateral ligament injected and relieved, only to have the patient return 24 hours later complaining of pain in the quadriceps tendon where a tender point can be found just above the patella. Following the injection of this point, the patient usually makes an uneventful recovery. In cases in which two or three injections are unsuccessful, we are inclined to feel that the cartilage is damaged, even though the history is atypical. If there is evidence of definite separation of the ligament, as demonstrated by marked abnormal mobility of the joint, the extremity is placed in a plaster cast following the injection. These, however, are not considered minor injuries. If excess synovial fluid is present, aspiration is performed. As demonstrated in Case 6, traumatic synovitis of the knee joint without localized tender areas responds rapidly to simple aspiration of the blood and injection of 10 cubic centimeters of 1 per cent novocain into the synovial sac.

CASE 7. Corporal H, while working on a new barracks building, fell from the roof, his abdomen

striking a plank as he landed, causing acute flexion of the lower back. On entry to the clinic, he complained of marked pain across the lumbar region. There was marked restriction of motion in the back. Spasm of both paravertebral muscle bundles was present. There was four plus tenderness over the left sacroiliac joint and tenderness over the muscles at their lumbosacral origins. X-ray examination was negative for fracture. Fifteen cubic centimeters of 1 per cent novocain was injected into the tender areas of both paravertebral muscles. Pain was completely relieved and full flexion of the trunk was possible. The back was strapped. Patient had no recurrence except for slight soreness which lasted about 4 days.

Low back pain is becoming a serious problem in our clinic, particularly with the induction of older men. The treatment is tedious and the response is slow. We have injected some of these cases in an effort to hasten the recovery, but our results are unsatisfactory in 41 per cent of the patients treated. It is worthy of note that in the main, these unsatisfactory results occur in those who have had old back injuries with chronically recurring attacks of pain. All back injuries are roentgenographed for bony lesions before treatment, and the possibility of a herniated intervertebral disc is always considered. If either bone injury or herniated disc is the cause of the pain, good results from novocain injection cannot be expected. The use of the injection of novocain in these cases, however, though not of therapeutic value may be of diagnostic aid, as noted by Hyndman, Steindler, and Wolkin.

In patients with acute low back strain, seen early, without previous history of injury, results are more favorable. In 1 case of sciatica of undetermined origin, infiltration of the piriformis muscle, as advocated by Haldeman and Soto-Hall, relieved the symptoms.

CASE 8. Private B jumped from a truck, slipped, and landed with his full weight on the extended right hand. Three days later, he came to the clinic complaining of pain and swelling of the right wrist. Examination showed crepitation over the lower third of the extensor surface of the forearm on flexion and extension at the wrist. A diagnosis of traumatic tenosynovitis of the extensor tendons was made. Ten cubic centimeters of 1 per cent novocain was injected into the most tender area. The crepitus disappeared and the pain was immediately relieved. Next day, the crepitus and pain had returned. A 2d injection was done, but the results were no better. The patient was finally treated with splinting at the wrist and physiotherapy with a good result.

TABLE I.—SUMMARY OF RESULTS

Site of injury	Excellent No.	Excellent %	Good No.	Good %	Poor No.	Poor %
Injuries of the ankle.....	30	73.2	10	24.4	1	2.4
Injuries of the knee.....	7	38.8	10	55.5	1	5.5
Miscellaneous injuries....	7	24.1	15	51.7	7	24.1
Injuries to lower back....	2	16.6	5	41.6	5	41.6

It should be noted that our results in 4 cases of acute traumatic tenosynovitis have been 100 per cent unsatisfactory: 2 cases with involvement of the extensor tendons of the wrist, and 2 with injury to the Achilles tendon. As a result of this brief experience, we have discarded injection treatment in such cases, and now prefer splinting and physiotherapy.

CASE 9. Private L was injured in a fight 7 months before he was seen at our clinic. From the time of injury, there had been pain in the left temporomandibular joint, and difficulty in adequately opening the mouth. Examination showed three plus tenderness over the region of the left temporomandibular ligament and moderate trismus. X-ray examination was negative for bone injury or subluxation. Two cubic centimeters of 1 per cent novocain was injected into the region of the temporomandibular ligament. Lower motor neurone paralysis of the zygomatic branch of the facial nerve developed but complete recovery ensued within an hour. The immediate results of the injection were the relief of pain and the ability to open the mouth readily and to a normal degree. Twenty-four hours later, the patient had no recurrence of his disability except slight soreness in the region injected. One week later, he was asymptomatic and has remained so.

This case is presented as one occasionally sees a similar condition in which the routine treatment is difficult and usually unsuccessful, while the injection of novocain may bring about prompt amelioration of the symptoms.

A number of miscellaneous injuries were treated. There were injected, with good results, 4 cases of shoulder and arm pain due to idiopathic myalgia, as suggested by Travell, Rinzler, and Herman. Five cases of sprain of the acromioclavicular joint without separation were injected with rapid recovery and with no immobilization. Five sprains involving the wrist were treated with good results. From 1 to 3 cases of the following conditions were injected, all with good results: calcification of supraspinatus insertion, subdeltoid bursitis, contusions of muscle, acute traumatic coccygodynia, and sprain fracture of base of first metatarsal.

SUMMARY

In attempting to shorten the period of disability caused by minor injuries, the usual conservative treatment has been discarded in favor of novocainization of the injured part. The results and our experiences in the use of this drug in 100 consecutive minor injuries are presented. The physiopathology of minor trauma and the changes produced by the injection of novocain are discussed. Our technique is explained and x-ray examination of the part before the institution of treatment is stressed.

The most commonly treated injuries and also the most responsive to the therapy were sprains of the ankle. No infections or toxic reactions resulted from the novocain injection. Rarely was more than the initial treatment with novocain necessary except in knee and back injuries. If favorable results are not obtained after 2 or 3 injections, further injection is not indicated. Typical case histories and a statistical study are presented.

CONCLUSIONS

Novocain properly used for minor injuries is of definite value as a therapeutic agent. Novocain injection decreases the period of disability, adds greatly to the comfort of the patient, and permits an early return to normal activity.

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THE EFFECTS OF RAPID COMPRESSION WAVES ON ANIMALS SUBMERGED IN WATER

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FOLLOWING the first World War Hooker (1924), reporting a series of careful investigations of the results of exposure of animals to the blast in air in the neighborhood of large (10 to 12 inch) rifles and mortars, stated (p. 219): "the exposure of animals anaesthetized or unanaesthetized to a sufficient air concussion leads to primary shock, i.e., a condition of low arterial blood pressure unassociated with hemorrhage and exposure." In the course of this investigation he observed the difference between the effects on animals of the blasts from the large rifles and of a series of high explosives. The latter produced effects "unlike those which resulted from exposure to gun blast and did not simulate the shock condition. The use of high explosive was therefore abandoned."

With the greater use of high explosives in the present war, interest in these has increased and Zuckerman (1940) especially has made available knowledge of the effects produced on animals at different distances from given charges in air. He reported that in a certain zone about an explosion exposed animals suffered hemorrhage of pulmonary and abdominal viscera; hemorrhage of spinal nerve roots, and (at high pressures) of the pia and ventricles of the brain. Zuckerman showed that trauma to the lung on one side of an animal could be diminished by covering that side of the chest with a rubber cushion.

Williams (1942) described the effects of exploding depth charges on swimming animals, and discussed blast effects in warfare. The journal in which these experiments were published was "delayed by enemy action," and we did not see it until most of the present experiments were completed. The pathological changes in Williams' animals were described by Cameron, Short and Wakely (1942). The chief findings were hemorrhage in lungs with rib markings evident, hemorrhages in the alimentary canal with occasional ones in epicardium, spleen, kidneys and ductless glands (the thymus of one animal and the adrenal of one). Interstitial emphysema was not uncommon. Hemorrhage was said to occur more frequently in the right lung than the left, the upper lobes and margins of the lung being the most common sites involved. Very little damage was produced in the soft structures of the body wall and the bones, and it was stated that there was no special tendency for the hollow, fluid containing viscera to be involved nor was the reproductive tract damaged. Some animals were killed at once and showed no marked pulmonary lesions. Perforations of the intestinal tract were not seen, though a dog directly over the depth charge had a ruptured stomach. There were areas of bruising and hemorrhage in the intestines which it was thought might have proceeded to ulceration and perforation if the animals had been allowed to live.

It has been stated that blast injuries in air occur predominantly in the thorax, while "immersion blast" injuries resulting from exposure to the detonation of high explosives under water are chiefly abdominal (Breden, d'Abreu, and King, 1942). If the reports of experiments and cases of blast injury are carefully examined it will be seen that cerebral concussion, while often mentioned as a result of blast actually appears less frequently than the pulmonary and abdominal trauma.

Experimenters have produced concussion in animals by blows to the head, an obviously effective method, and various explanations of the cause of the resulting disturbance of nervous function have been proposed, the most

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recent one being a sudden acceleration or deceleration (Denny-Brown and Russell). Mott (1916) suggested that with the compression of the chest by a blast in air, cerebral concussion might be produced as a result of a wave of pressure traveling along the blood columns of arteries and veins which enter the cranium, thus affecting the central nervous system. This theory has appealed to Stewart, Russell, and Cone (1941) and was supported by King and Curtis (1942), and others; and it was with the idea of testing it that the present experiments were undertaken, though study of the other effects of immersion blast was also a major aim.

METHODS[1]

In searching for a means of producing waves of compression about the body without the inconvenience of explosives, it seemed reasonable to set up waves in water surrounding the experimental animal. In order to produce compression waves in water an apparatus was constructed which was patterned after the following original experiment that Dr. John Daniels, emeritus professor of physics at Vanderbilt University, was accustomed to demonstrate to his classes. In his demonstration an iron U-tube was constructed, with one end made of glass. It was filled with water, both ends were left open, and in the end that was not glass a plunger was placed. The application of a sharp blow with a hammer to the plunger resulted in shattering the glass portion at the other end of the tube though the whole system was open to atmospheric pressure.

For the experiments reported here a U-tube 28 inches high (Fig. 1) made of steel pipe 6 inches in diameter was set upright in a rack and filled with water or saline. A wooden plunger with a diameter approximately ½ inch less than the inside diameter of the tube, made with a shoulder that would prevent the plunger from being driven entirely into the tube was placed in the water filled pipe so that it floated with its shoulder 1 centimeter above the top of the pipe. Above this end of the pipe two vertical steel wires were stretched to act as guides for a rack carrying a falling weight. A tripping device allowed the rack to be released at any distance desired up to 5 meters above the plunger. Weights ranging from 425 grams to 7700 grams were used.

To operate the apparatus an animal was placed in the water in the open end of the U-tube, with the plunger floating in the other end. When ready a known weight was dropped onto the floating plunger from the height selected. As a rule animals were enclosed in a snugly fitting tubular cage of hardware cloth (½ inch mesh) so that all could be placed in comparable positions. Such a cage facilitated the handling of the unanesthetized animals. With the apparatus experiments have been conducted on 112 rats, 31 mice, and 8 cats. Of these, 39 rats and all 8 cats were under nembutal anesthesia; the remaining rats and all mice were unanesthetized. Two mice were submerged in a can of glycerine which was suspended in the water filled pipe. Electroencephalograms[2] (with records of heart rate and respiration) were taken on 8 rats and the 8 cats.

RESULTS

When a weight of sufficient size was dropped from an adequate height animals were killed within a few minutes as the result of exposure to one impact. With lighter impacts animals survived the blow for longer periods or recovered completely. Immediately following a lethal impact the heart was quickly but temporarily slowed to half, or less than half, its original rate. Breathing was stopped for a period of a few seconds to more than a minute and respiratory movements, if temporarily reestablished, were usually labored and apparently ineffectual for respiration and were finally accompanied by nose bleed. Early signs of the effects of the intra-alveolar pulmonary hemorrhage could be detected with a stethoscope. Failing respiration was accompanied by a failing heart. If the vagus nerves had been cut, respiratory movements continued after a blow without interruption (but with some slight slowing) until stopped with the death of the animal. After section of the vagi the heart rate was slowed at first only by about 10 per cent of its rate and then might

[1]Dr. Newton Underwood of the department of physics was most helpful in our experiments.

[2]The electroencephalographic apparatus used in these experiments was made available by a grant from the John and Mary R. Markle Foundation.

speed up but become slower as the animal's lungs filled and death approached. Though an animal might run or walk normally just after the blow it soon became ataxic and incoordinate and died. Death usually occurred in 2 or 3 minutes, but was delayed in some animals for longer periods. Although occasional animals showed loss of corneal reflexes, ataxia and incoordination immediately after the blow, it was exceptional that any of these signs suggestive of direct and immediate involvement of the central nervous system occurred. They did, however, occur later as anoxemia followed the difficulties of respiration. Electroencephalograms have so far failed to confirm evidences of concussion at the time of the impact. The results of this and associated studies on the electroencephalogram in concussion will appear in another report.

Findings at autopsy were constant in animals dying shortly after an exposure to one impact, the most conspicuous being massive pulmonary hemorrhage. The lungs were as firm to the touch as liver and were deep red over most portions and throughout the lobes, though the apices were usually spared or were less hemorrhagic than the rest of the lungs, and if the hemorrhage was not maximal the bases were spared (Figs. 2, 3, 4). It was exceptional to find blood in the pleural cavity. The animals evidently bled to death in their own lungs and as a result there was little blood on the systemic side of the circulation. The weight of the lungs at autopsy of animals with massive hemorrhage was four or five times that of a normal animal. Cutting the tissues of the body wall of such animals resulted in no bleeding, and the entire animal was pale. Even the abdominal viscera bled but little on cutting. There was no consistent engorgement of abdominal veins.

The intestinal tract, which was also the site of serious damage, showed scattered bruised, hemorrhagic areas in the cecum, colon, rectum, stomach, and small intestine. The cecum, lower ileum, and stomach were the regions most frequently affected but the number and severity of these lesions varied from animal to animal and were not as constant as the damage to lungs. In addition there were occasional punctate ruptures of the stomach or intestines, allowing the escape of blood and intestinal contents into the peritoneal cavity. There was also in some animals hemorrhage into the lumen of the stomach and intestine without rupture of the serous coat.

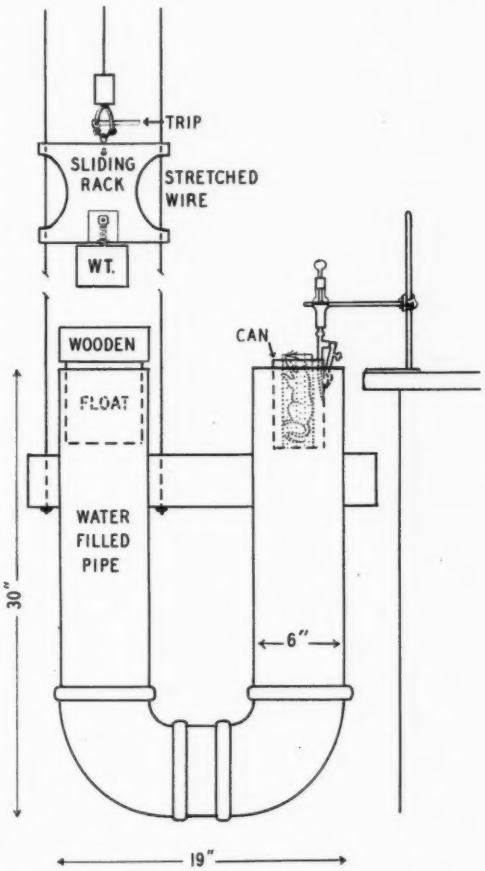

Fig. 1. Diagram of the U-pipe apparatus used in producing the impacts described in the text. The rat is represented as being in the wire meshed cage and this in the water filled can. The weight was released automatically while being drawn up when the "trip" struck a rod set at the proper distance above the wooden float.

The solid viscera, liver, spleen, and kidneys, very rarely showed damage and the bladder was not visibly injured whether it was more or less distended at the time of the blow. The reproductive system showed no gross lesions and neither the pregnant uterus nor its contents in one animal was visibly damaged.

The brains and spinal cords showed no evidence of gross hemorrhage or damage. Sections of these structures are being prepared for study. The muscles, body walls, and skeletal framework were apparently uninjured.

Although there was no large amount of water surging in the pipe at the time of the impact, it was thought possible that this might play a part in the injury. To avoid the effects of such surges a tin can, open at the top, was almost filled with water and suspended by a clamp in the end of the U-pipe so that its water level was about the same as the water level in the pipe surrounding it (Fig. 1). The experimental animals were then placed in the water in the can, and were thus protected from large movement of water in the pipe. The effects upon the animals were similar to those placed directly in the pipe, although the can appeared to give a slight protection from the effects of a given impact.

After the first few experiments were performed it was observed that the effects were not always the same on successive animals with the same impact (same weight and height of fall). By repeated testing the following were found to affect the results of impact:

1. The size of the falling weight. The greater the weight from a given height, the greater the damage to animals of the same size (Figs 3 and 4).

2. The height the falling weight dropped. The greater the height a given weight dropped the greater the damage to animals of the same size (Figs. 2 and 3).

3. Size of the animal. The larger the animal the less the effect for a given impact. A weight (4350 gm.) that caused the death of a 20 gram mouse when falling 40 centimeters had to fall 1.5 meters to kill a 300 gram rat, and 4.5 to 5 meters to kill a 2 kilogram cat. A weight (1800 gm.) dropping 2.5 meters killed a rat weighing 175 grams but had to fall 5 meters to kill a rat weighing 260 grams.

4. Position of the animal. If an animal was allowed to hunch itself up in the water as a rat does in swimming it was not as seriously affected as if it was stretched out in its wire cage with all sides equally exposed.

5. Amount of submersion. Only that part of the animal below the water level at the time of the impact showed the typical lesions. For example, if the animal's caudal end was immersed up as far as the diaphragm, the typical abdominal trauma resulted, but the lungs were spared; if the animal was immersed to the middle of the thorax, the upper part of the lungs were spared when an impact was applied that was lethal to the fully immersed animal. It is of significance that such incompletely immersed animals did not die immediately from the blow if a sufficient amount of the lung escaped trauma and hemorrhage.

6. The state of inflation of the lungs. Damage was greater to fully inflated lungs than to deflated lungs. An animal's life could be saved by holding its lungs in a state of deflation with the aid of an intratracheal cannula at the time of an otherwise lethal impact.

7. The presence of protective coverings. Wrapping a rat in a cork life preserver (3 mm. in thickness) or a sponge rubber one (5 mm. thick) resulted in saving the regions covered from much of the effect of an otherwise fatal blow.

8. The presence of air in viscera or tissues predisposed to damage in that area. For example after injecting air subcutaneously and allowing it to spread about in small bubbles, exposure of the animal to immersion impact resulted in hemorrhage in the region of subcutaneous emphysema and not in other subcutaneous areas. When by laparotomy a segment of intestine was tied off and filled with air it showed marked bruising and hemorrhage after an impact to the animal while neighboring collapsed segments of gut were spared. The presence of isolated gas bubbles in the intestine was apparently the explanation for the localization of damage. When rupture of the gut had occurred gas bubbles in the peritoneal cavity have been observed at autopsy.

Since evidence of cerebral concussion was rare in these experiments a few attempts were made to produce it by immersing a part or all of the head of the animal in the water at the time of a blow. Concussion was not produced by blows within the limit of the apparatus upon the intact head of rats or cats or upon two cats with a half square centimeter of the calvarium removed (in one over the vertex of the cerebrum and in one over the cerebellum)

with that part of the head submerged. However, the heart was markedly slowed following an impact in the cat with the exposed cerebellum. With tracheal cannula in place it was possible to submerge the head of an anesthetized animal. An intact animal could be quickly ducked head down in the pipe long enough for the impact to be applied. Bleeding of the nasal mucosa and swelling sufficient to make breathing difficult followed such a procedure in rats, but concussion did not result.

OBSERVATIONS AND COMMENT

The method used in these experiments of producing a wave of compression in water surrounding an animal has certain obvious advantages over the use of explosives. It is possible to control the magnitude of the impact, and to measure its wave form. The animal can be completely or partially subjected to the effects of an impact which can be graded so that it produces little to maximal damage. Recording of electroencephalograms and electrocardiograms is possible during an experiment, and, of even more significance, the animal and its reactions can be observed at all times, even at the moment of impact.

While Hooker and Zuckerman were able to observe the immediate effects on animals of blast in air, most of the observations on people subjected to immersion blast have been made hours after the experience, though the testimony of those affected has aided in filling in the early part of the story. There was also a lapse of time in the experiments described by Williams between the setting off of the depth charges and the collection and observation of the exposed animals.

The pathological effects of the impact in these experiments, are so similar to those produced by high explosives in air and to those observed following immersion blast as described in the literature (Cameron, Short, and Wakely) that little description is necessary. Recent reviews of literature have been given in the article by Zuckerman, King and Curtis, and Williams.

Physically the impact obtained from dropping the weight on the floating plunger sets up waves in water having characteristics similar to those produced by setting off an explosive under water. Both produce primary "compression" waves of extremely short duration. Preliminary measurements by means of piezo-crystal and cathode-ray tube with our apparatus indicate that the wave, like that about a discharge of high explosive in air, occurs in about 1/5000 of a second (exact measurements are yet to be done). It presumably travels at the speed of sound in water (5657 ft. per sec. at 60°C; 4714 ft. per sec. at 15°C). Williams brings out in his discussion of blast (p. 42) that, "the pressure wave in water travels at the same speed as it does first in air, i.e., 5000 feet per second, and it should be noted that this is the same as the speed of sound in water." The surge of water produced by the expansion of gases about an explosive is absent with our apparatus.

That the effect on the animals in these experiments is not due to a slow surge of any large amount of water is indicated by the experiments in which the animal was placed in water in a metal can and this in the pipe. No surge of water was possible with this arrangement yet the effects were the same except for a slight diminution of the effect on the animals in the can. A rapid wave of compression (water and metal being relatively incompressible) however could travel through such a system readily. It may be that the reflection of the wave in the pipe used produced a slightly different situation from that in open water. However, an interesting commentary on this phase of the experiments was given us by Dr. H. C. Francis who stated that as a boy he had "stunned" fish by hitting exposed rocks along streams with a hammer. Another acquaintance told us of killing fish in an ice covered stream by dropping rocks on the thick ice, not breaking the ice but killing the fish which floated to the surface at a nearby unfrozen rapid. Fish killed at sea near depth charge explosions show little or no pathology (Breden, d'Abreu, and King).

In these experiments if an animal did not die from a given impact in a few minutes, its chances of survival were greatly increased. If the lungs were not damaged sufficiently to prevent successful respiration the animal would survive to take its chances with the delayed results of shock from blood loss, or

peritonitis from ruptured intestines, or other difficulties. Zuckerman has pointed out that healing of the damaged lungs is very rapid in animals exposed to blast in air even though respiratory embarrassment persisted a day or more.

Breden, d'Abreu, and King state (p. 145) "it is probable that in 'blast' injuries at sea the abdomen is affected more than the chest, and in this way contrasts with the picture seen in blast injuries of air raid casualties." In the symposium on immersion blast injuries in the *Naval Medical Bulletin* (January 1943) it is stated by Palma and Uldall (p. 8), "Immersion blast injury produced by the detonation of high explosives in the water is characterized chiefly by abdominal pathology with secondary effect in the bases of both lungs and the central nervous system." Other writers have also expressed similar opinions. In our experiments, however, pulmonary damage was the most conspicuous form of injury and the obvious cause of the immediate deaths from severe impacts, and this appears true in the experiments of Williams. It would seem, therefore, that the reported greater effect on the abdominal region of people exposed to immersion blast is not based on any greater susceptibility of the abdomen to damage. In fact it is obvious that the lungs are more likely to be damaged severely than are the abdominal viscera when both regions are subjected to the same impact. However, many of the individuals who are exposed to blast in the sea are wearing life belts at the time, and this tends to protect the lungs from damage. And there are additional factors for protection in the position of the person at the time of the explosion; his orientation to the blast, the stage of respiration, the amount of submersion, and even the clothing that may be about the body.

On the other hand, those individuals in the sea at the time of the explosion who are not protected by any of the above factors very likely receive the greatest damage in the lungs. Of these, if we can judge by experimental results and the personal accounts of survivors, many probably die of pulmonary hemorrhage in the first few minutes; and others who survive longer are faced with the necessity of struggling to keep afloat, or clinging to a raft. No doubt some of the most severely injured of this group do not survive long enough to be treated or observed by medical men. Those less severely injured may be able to exert themselves until rescued and so live to show their abdominal injury. Considering then the entire group of exposed individuals, the most severely injured immersion blast cases are probably weeded out before observation. On land, where an injured person may, at least physically, relax until aided, most of the victims of blast injury may come under observation. It is likely then that many of those experiencing pulmonary damage of a severity that would have been fatal to a swimming man are found and observed by medical attendants before death.

The inadvisability of more than the necessary minimum of voluntary or even passive movement after exposure to concussive blasts is stressed by several authors. The animals in these experiments often appeared almost normal just after exposure to impact but died after sufficient hemorrhage had occurred in the lungs. We have indeed observed sudden changes for the worse in animals that made struggling movements after a period of quiet. Even the increased efforts at respiration as the air spaces in the lungs filled with hemorrhage seemed to be accompanied by further filling of the air passages and finally a flow of blood from the respiratory passages. This suggests a possible explanation for an incident recorded by Williams in which 7 men were exposed to a blast on a ship in the Norway campaign. All managed to get ashore. One who was too ill to stand was carried by his 6 comrades and put to bed in a shelter. The sick man survived but the other 6 were dead the next morning.

The protection afforded by even a thin covering of compressible material emphasizes the importance of the use of life belts in water (or for that matter in air) as protection against blast injury. The "knight's armor" developed and used by Commander Knight (Williams 1942) in the measurement of blast pressures demonstrated the efficacy of such protection in air, as did Zuckerman's experiment with sponge rubber covering of animals. The protective effect of life belts (and favorable positions) on men swimming near explosives

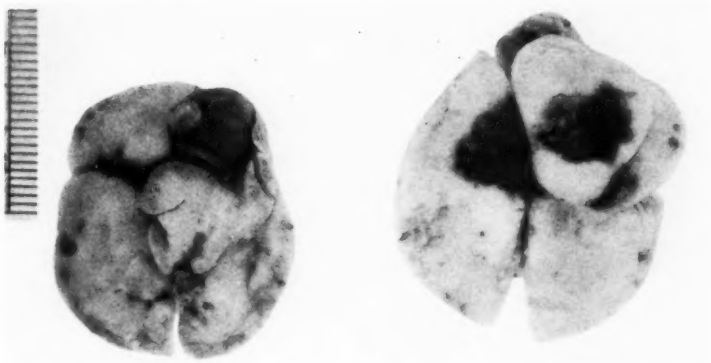

Fig. 2. Bases (left) and dorsal aspect (right) of lungs of an unanesthetized rat subjected to an impact while submerged to the neck in water. Rat weighed 180 grams; falling weight 1800 grams; height of fall, 3 meters. Scattered small hemorrhages visible on bases. More marked hemorrhage on dorsal midportion of lungs. The animal survived but was killed 30 minutes after the impact was applied.

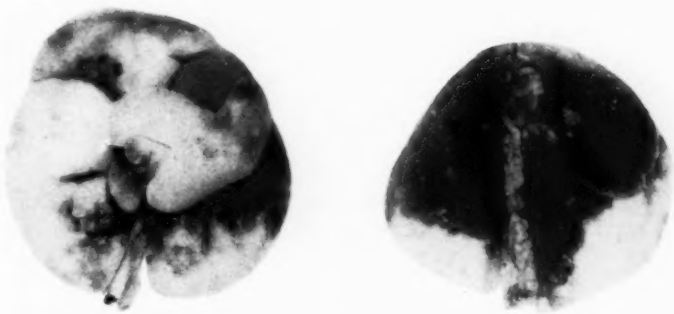

Fig. 3. Bases (left) and dorsal aspect (right) of lungs of an unanesthetized rat subjected to an impact while submerged to neck. Rat weighed 180 grams; falling weight, 1800 grams; height of fall, 4 meters. Note the greater hemorrhage on both surfaces as compared with Figure 2. The apices were spared but are not shown in the picture. Note also sparing of the lower margins posteriorly. The animal bled at the nose but did not die immediately. It was killed 10 minutes after the blow.

in water was noted also in the recent symposium in the *Naval Medical Bulletin.*

The experiments by Williams (1942) on animals in the sea in the neighborhood of depth charges gave results strikingly similar to the ones reported here. An interesting difference in results, however, is worth notice. In the case of 2 of Williams' dogs exposed to the blast, 1 was protected by a rubber jacket over its abdomen, the other by a similar jacket over its chest. The damage to the lungs was described and pictured as greater in the animal with its *chest* covered than in the one with its *abdomen* covered. The explanation suggested was that the pressure via abdomen and diaphragm was effectively greater than that through the chest wall. It seems likely from our experiments that since these dogs were swimming some differences in posture or the effectiveness of the covering, or in the stage of respiration, or in the content of gas in the intestinal tracts at the time of the explosion

Fig. 4. Bases (left) and dorsal aspect (right) of lungs of an unanesthetized rat subjected to an impact while submerged to the neck. Rat weighed 180 grams; falling weight, 4350 grams; height of fall, 4 meters. Observe the greater hemorrhage from the fall of a heavier weight. Note the sparing of the midportion of the base, and that more hemorrhage occurred in the right lung than in the left. The animal bled at the nose and died 1 minute after the impact.

was the explanation of the apparent reversal of the expected result. That pressure from the abdomen on the lungs is not as significant a cause of lung damage as the lateral pressure on the thorax is indicated by the fact that the portion of the lungs in the rat over the middle of the diaphragm (especially the azygos lobe of the right lung) was commonly fairly free of damage after a lethal blow. This is further supported by the results of partial submersion where the damage appeared only in those parts near or below the water level. Cameron, Short, and Wakely noted in Williams' animals that severe hemorrhage was much more frequent in the right lung than in the left, an observation which was often true in submaximal pulmonary hemorrhage in our rats. The explanation for this is not obvious.

That cerebral concussion was not the common result of these experiments is interesting. Perhaps greater impacts might have produced concussion regularly, but since animals died within a few minutes from pulmonary hemorrhage with the impacts used, the problem of the influence of cerebral concussion becomes of minor importance in terms of survival.

The instantaneous deaths of people subjected to blast may be, as suggested by Mott, the result of a suddenly applied compressive wave that is transmitted by way of the tissues to the cerebrospinal fluid and central nervous system resulting in instantaneous arrest of the function of the cardiac and respiratory centers. Williams and his associates had some animals killed without marked pulmonary hemorrhage, and these may have been instantaneous deaths. Under such conditions the trauma to the lungs may have been present but the sudden stoppage of blood flow and respiratory movements could have been the reason for the small amount of hemorrhage. Denny-Brown and Russell (1940) state that concussion is potentially fatal without macroscopic lesions of the brain stem. Hooker, from observations on animals in his experiments not immediately killed, states that, whatever injury to the nervous system was caused by air concussion, it did not destroy the functional activity of medullary centers. He observed that sight and hearing were present in the unanesthetized animals after exposure, and in all animals the respiration continued, while in the anesthetized ones the corneal reflex was very active until just before death. He pointed out, however, that these observations do not exclude a functional disturbance in the medullary centers, especially those dealing with heart rate and vascular tone.

Hamlin (1943) discussed the neurological observations on the patients considered in the *Navy Bulletin* symposium rescued after exposure to immersion blast. He suggested that a

blast wave of sufficient magnitude may be transmitted to the spinal canal and then to the cranial cavity, setting up a force through the spinal fluid, and possibly the central nervous system itself, which might be analogous to the phenomenon of cerebral acceleration that follows a solid blow to the head. He states, however, that the brief unconsciousness after immersion blast which occurred in many of his patients was probably more often caused by a rapid shift in the vascular reservoirs of the great vessels producing transient ischemia of the brain rather than concussion. Effects from compressive waves of longer duration may result in neurological symptoms even if the more rapid ones do not. The case of crushing and compression of the chest described by King and Curtis was of the sort allowing time for transmission of fluid pressure to the cranial cavity.

Recognition of concussion is not always easy. Clinically it is described simply as loss of consciousness following trauma, with recovery and no accompanying pathology. Experimentally since the state of consciousness in an anesthetized animal is an impossible criterion other standards must be set. Denny-Brown and Russell (1941) have described concussion produced by blows on the head as an immediate but transitory paralysis of all bulbar reflex mechanisms they examined, accompanied by an original "start reflex," bradycardia with a respiratory pause, and fall in blood pressure, various motor effects, and a transient rise in blood pressure. The last is said to be related to the phase of traumatic paralysis and may obscure the fall in blood pressure just mentioned. It has been observed in the present experiments that the heart rate markedly slows immediately following a heavy impact, though it may increase with a light one. Only slight slowing of the heart occurs if the vagus nerves have been previously cut. The respiration is inhibited at the time of a heavy impact unless the vagus nerves have been severed. After an interval (a few seconds to more than a minute) respiratory movements begin again, and the animal may survive. Efficiency of respiration and survival seem to be correlated with the amount of pulmonary hemorrhage.

The effect of previous sectioning of the vagus nerves on the cardiac and respiratory rates after the impact suggests that the variations in these rates may be due to afferent impulses over the vagus nerves rather than concussion of the central nervous system. The mild slowing of the heart that occurs after section of the vagi could be due to the effects of the alteration in the filling of various heart chambers and vascular channels secondary to the changes in blood flow through the traumatized lungs. Inhibition of accelerator nerves to the heart may be involved.

While some of the phenomena of concussion have been observed in our experiments at the time of the impact, especially the respiratory disturbance and slowing of the heart, the unanesthetized animals which had received a lethal blow were obviously not suffering from concussion in the first minute or so afterward. It is true the animals later showed loss of awareness and of reflexes, but this was apparently associated with the marked respiratory distress and internal hemorrhage. As death approached, the color faded from the eyes and exposed mucous membranes of the rats, while the gasping respiratory movements were obviously ineffectual.

The influence of air in lungs and hollow viscera, and in subcutaneous regions (previously injected) is apparent from the account of the experiments. In this connection Williams states from observations on animals in water near depth charges (p. 42) "When the pressure wave impinges on the body there will be no reflection, but the pulse will be transmitted through the tissues without displacement, just as if the body were so much water. However, when the transmitted pulse encounters an air cavity in the body, e.g., the lung, . . . the static wave of pressure will change into a wave of kinetic energy in the layers of tissue lining that cavity and a disruptive effect will occur."

The absence of damage in various body tissues, the brain, the solid viscera, and the water filled bladder of our animals is thus understandable. The amount of pressure necessary to cause disruption of tissue with air on one side of it is obviously not sufficient to injure seriously tissues which may be considered as completely permeated with water.

Our animals did not lose reflexes in the areas exposed to impact so even the peripheral nerves and endings must be able to withstand these pressures. That concussion of peripheral nerve fibers is possible with an air blast was shown by Krems, Schoepfle, and Erlanger (1942). Perhaps the animals and people who have suffered instantaneous death were subjected to much higher impacts. It is of course known that the application of local blows to the body have resulted in sudden death without demonstrable pathology but other causes than concussion may apply here. Perhaps cerebral concussion is more likely to be seen when the head is exposed to an excessive blast from which the body is so protected that pulmonary hemorrhage is avoided. Concussion which follows a blow to the head from a flying object or from the individual's head striking something solid as the result of a blast is a different matter. Scott (1940) has recorded sudden increase of intracranial pressure to heights above systolic blood pressure in dogs when unconsciousness followed a blow to the head.

In man the effects of nonlethal blasts on the nervous system have been stressed as contributing to the various neuroses of war (Mott, 1916; Carver, 1919). Russell (1942) states that in civilian cases the incidence of post-concussional symptoms is lower than generally realized and the duration of disability surprisingly short. It was true in our experiments that animals exposed to impacts which were not fatal in the first few hours tended to recover rapidly.

SUMMARY AND CONCLUSIONS

1. A method is described for subjecting animals to shock waves in water by dropping a weight on a floating plunger. The method allows continuous observation of animals throughout the experiment. Submerged animals exposed to an adequate impact in the apparatus died within a few minutes.

2. The effects of the impacts produced in these experiments were similar to those described in the literature as resulting in nearby animals and man from the detonation of explosives in water and in air.

3. Pulmonary damage with marked hemorrhage into the lungs was the cause of immediate death in the animals in these experiments.

4. Abdominal injury was largely confined to the gas-containing portions of hollow organs, with hemorrhage in the walls and lumina and occasional perforation.

5. The following factors modified the results: size of the falling weight and the height it dropped, size and position of the animal, the amount of submersion, the state of inflation of the lungs, the quantity and position of protective coverings, the presence of air in viscera or tissues.

6. Cerebral concussion was not the common result from the impacts used in these experiments. The animals died of other causes.

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OSTEOGENIC SARCOMA

I. A Modified Nomenclature and a Review of 118 Five Year Cures

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THE organization in 1921 of the Registry of Bone Sarcoma, by the late Dr. Ernest Amory Codman, was the beginning of a co-operative group effort in the study of a complex group of neoplasms. There was extant a large mass of information, clinical and pathological, concerning bone sarcoma but the individual blocks of knowlege failed to fall into place largely because there existed no accepted "blueprint" of nomenclature, no established concepts as to the histogenesis and natural history of tumors of bone. Organized under the aegis of the American College of Surgeons and maintained as a research problem by that organization since 1922, there are now some 2,400 cases in the Registry. The signal achievement of the Registry has been in the review and analysis of pertinent material from this large number of bone tumors by a committee composed largely of pathologists and surgical pathologists, a method of attack which has now been emulated in the study and clarification of other groups of neoplasms. The success which has attended this co-operative effort is aptly illustrated by the contrast between the nomenclature of bone tumors first adopted in 1923 and the last revision published for the committee by Ewing in 1939, parts of which are shown respectively in Tables I and II. Some sort of order has thus been brought out of terminological chaos as the criteria of different bone tumors have been recognized and their histogenesis to some extent established.

The whole field of tumors of bone nevertheless still offers many unexplored areas, and ideas concerning sarcomas of bone are considerably more fluid than in most other divisions of oncology. Ferguson, for example, recently has questioned even so established a principle as early amputation. The Registry material constitutes an orderly, documented mass of information of unparalleled value in the investigation of bone sarcoma. This study is based on material from this source, and is confined to those malignant tumors arising in the connective tissue elements of bone, the "osteogenic" sarcomas.

The revised classification of 1939 placed the bone tumors of connective tissue origin into two groups, the osteogenic series and the chondroma series. The osteogenic series as classified by Ewing included those neoplasms that form bone as well as those which histologically were strictly fibrosarcoma, while the chondroma series had been split off from the general group of osteogenic sarcoma as a separate entity. In 1941 the Registry of Bone Sarcoma reported 1,022 registered cases of "osteogenic" sarcoma. Of this number 654 had been treated 5 years or more prior to 1941 and only 97, or 14.8 per cent, were accepted as five year cures. One hundred fifteen instances of chondrosarcoma, with 21 five year cures (11 per cent) had been found in the material, with other examples of chondrosarcoma undoubtedly remaining unidentified without a complete survey of the entire collection.

This group of 118 five year cures of a highly lethal type of neoplasm offered a challenge to a critical review of their clinical and microscopic features and of the therapeutic methods by which they had been treated. It was anticipated that differences might be found in a comparison of the cases of patients cured with an equal series of cases of uncured patients to be unselected except for comparable regional incidence. Through the co-operation of the Registry it has been possible to study the case histories, roentgenograms, and microscopic slides of the entire cured group, but the present emergency has interrupted the study with only 47 fatal cases reviewed.

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TABLE I.—CLASSIFICATION (1923) OF BONE SARCOMA REGISTRY (OSTEOGENIC TUMORS)

2. Periosteal fibrosarcoma
3. Osteogenic tumors
   Benign:
   a. Exostosis
   b. Osteoma
   c. Chondroma
   d. Fibroma
   Malignant:
   a. Anatomic types
      Medullary and subperiosteal
      Periosteal
      Sclerosing
      Telangiectatic
   b. Undifferentiated sarcoma

TABLE II.—CLASSIFICATION (1939) OF BONE SARCOMA REGISTRY (OSTEOGENIC TUMORS)

	Malignant	Benign
1. Osteogenic series	1. Medullary and subperiosteal	1. Exostosis
Osteogenic sarcoma	2. Telangiectatic	2. Osteoma
	3. Sclerosing	
	4. Periosteal	
	5. Fibrosarcoma (a) Medullary (b) Periosteal	
	6. Parosteal, capsular	
2. Chondroma series	1. Chondrosarcoma	1. Chondroma
	2. Myxosarcoma	

During the review of the 118 cases of cures it became evident that few of these tumors presented the microscopic criteria of bone producing sarcomas. Thirty-seven (31 per cent) are tumors characterized by a spindle cell morphology with a fibroblastic type of stroma. Fifty-six (46 per cent), in our opinion, belong to the newly created chondroma series and only 14 (12 per cent) can be called true bone-producing sarcomas. In only 4 instances the tumor shows sufficient differentiation toward more than one type of tissue to justify compound names. Six cases studied are regarded as not belonging in this series of tumors.

These findings are in sharp contrast to those of the uncured group. As far as the analysis had been carried only 15 per cent of the latter group have a fibroblastic structure while cartilage and bone forming properties are found with equal frequency in the remaining 85 per cent.

Since the histological structure observed in the majority of sections studied seems to consist predominantly of one of the three fundamental types of connective tissues this offers the most logical basis for a classification of the primary malignant tumors of osseous tissue. More than a decade ago Phemister outlined clinical, roentgenographic, and histological criteria of cartilaginous tumors sufficiently distinctive to merit the recognition of chondrosarcoma as a special type of bone tumor. We propose to ascribe clinical and microscopic features and a numerical importance to fibroblastic tumors which should justify their inclusion as a group of neoplasms comparable in significance to the chondroblastic tumors.

There is need for a specific term for the designation of the third or bone producing member of the triad of connective tissue tumors arising in bone, since the term "osteogenic" is properly interpreted as implying only "originating in bone" and not specifically "forming bone." For this purpose the term "osteosarcoma" formerly employed by Mallory, Ewing, and others seems inescapable.

Based on these considerations, the following modified classification of malignant connective tissue tumors of bone is therefore proposed with their benign counterparts included.

	Malignant		*Benign*
Osteogenic series	a. Osteosarcoma b. Chondrosarcoma c. Fibrosarcoma	Osteogenic sarcoma	Osteoma Chondroma

The designation of subvarieties of osteosarcoma based on pathological anatomy appearing in Table II may be listed under (a), but this primary division adheres more rigidly to a pattern of histogenesis.

The term osteosarcoma is used here to include only those neoplasms in which an osteomucoid matrix is being formed. A fibrillar or mucoid substance may be evident in many areas, but a search of well preserved and viable areas of tumor reveal anastamosing trabeculae of a dense, homogeneous, formed stroma which trap the adjacent cells in the ground substance.

Chondrosarcoma includes the group of neoplasms characterized by a formed hyaline stroma. The cell morphology is highly variable but usually is round or oval where the matrix is solid. In the frequent areas of mucoid change stellate and spindle forms are usually observed. Intercellular substance may be

TABLE III.—RELATIVE INCIDENCE OF TYPES OF OSTEOGENIC SARCOMA

	5 year cures		Uncured	
	No.	%	No.	%
Osteosarcoma	14	11.8	19	40
Chondrosarcoma	56	47.5	19	40
Fibrosarcoma	37	31.4	7	15
Complex sarcomas	4		1	
Not diagnosed	1		1	
Nonosteogenic	6			
Total	118		47	

TABLE IV.—CLINICAL FEATURES IN 3 TYPES OF OSTEOGENIC SARCOMA

	Osteosarcoma		Chondrosarcoma		Fibrosarcoma	
	5 yr.	Uncured	5 yr.	Uncured	5 yr.	Uncured
Average elapsed time in months from onset to amputation	11.4	6.0	8.6	9.0	18.0	11.0
% in which biopsy done	50	31	59.4	52	64.8	*
% irradiated	42	52	46	52	56.7	*
% in which tendency to encapsulation observed	33	0	57.9	0	73	*

*Inadequate material.

noted only in islands in which the cells are more or less evenly distributed through a glassy matrix. There is a marked tendency toward calcification and in some tumors, due to necrosis, only the calcium deposits remain in large areas of the tumor.

The osseous fibrosarcomas are fundamentally similar to fibrosarcoma primary elsewhere in the body. They are characterized by a stellate or spindle cell morphology with wavy bundles of collagen fibers criss-crossed or intertwined. Retrograde changes are very prominent with hyalinization, mucoid degeneration, and calcification of frequent occurrence. Secondary bone formation is to be found in hyalinized or calcified stroma, and occasionally sufficient osteogenesis is encountered to justify the diagnosis of ossifying fibrosarcoma. This feature is observed as frequently in fibrosarcomas of soft tissue as in those of osseous origin. In practically all of the fibrosarcomas studied the evidence offered by roentgenograms and gross anatomical descriptions is such as clearly to indicate their origin in bone. Thus they are not related to the spurious pretenders to osteogenic status, parosteal and capsular sarcomas, nor were any of them associated with neurofibrosarcomatosis. In one instance fibrosarcoma had developed in Paget's disease. Some of these tumors seem to have been medullary in origin, others periosteal, but we believe that many also originate in cortical bone.

In rapidly growing bone sarcoma the cells may be so immature that no connective tissue is observed, and the tumor is therefore indifferent. In the majority of cases, however, sufficient evidence of functional differentiation can be found to warrant classification in one of the three groups. The functional differentiation is usually predominantly of one type, and in only a small percentage of the tumors is a diagnosis of a mixed pattern deemed necessary. Some of the more anaplastic chondrosarcomas in which cartilage is lacking offer considerable difficulty, and are recognized by the unusual epithelioid or polyhedral cell morphology mentioned by Ewing.

The relative frequency of the three forms of osteogenic sarcoma is summarized in Table III. The incidence of osteosarcoma and of fibrosarcoma in the cured and uncured groups is so inversely proportional as to confirm the known extraordinary degree of malignancy of true bone producing sarcomas (osteosarcoma). Although chondrosarcomas account for the largest single number of cured cases, they occur in equal incidence with osteosarcoma in the smaller series of uncured patients. As the extreme variation in microscopic structure would suggest, chondrosarcomas may range from a well differentiated tumor of debatable malignancy to a highly anaplastic, osteolyzing neoplasm. Fibrosarcoma is the least malignant member of the triad, a tumor of slow or even indolent growth generally late in its metastases. Some of them resemble certain fibrosarcomas of soft tissues in this latter respect.

The amount of matrix formed by any of the three tumors seems unimportant as a prognostic feature. The ability of the host to accomplish some degree of encapsulation of an osteogenic sarcoma must be regarded as a most

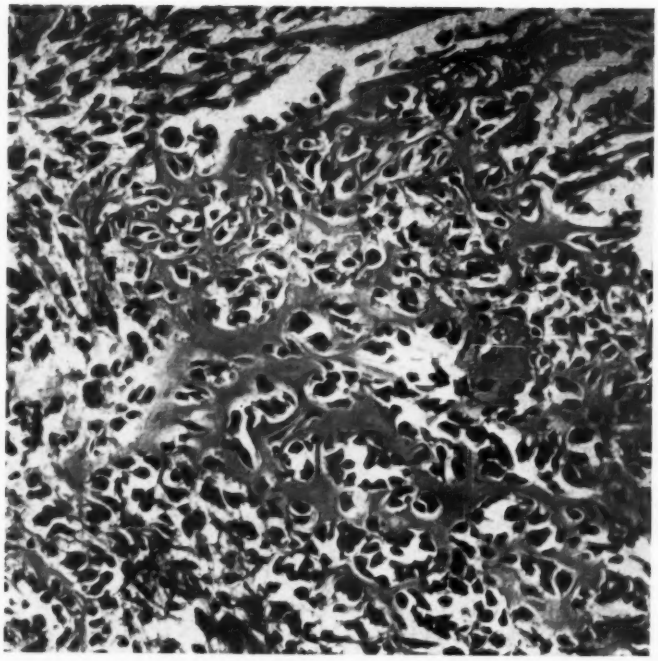

Fig. 1. Osteosarcoma. Well formed anastomosing trabeculae of bone. B.S.R. No. 1239.

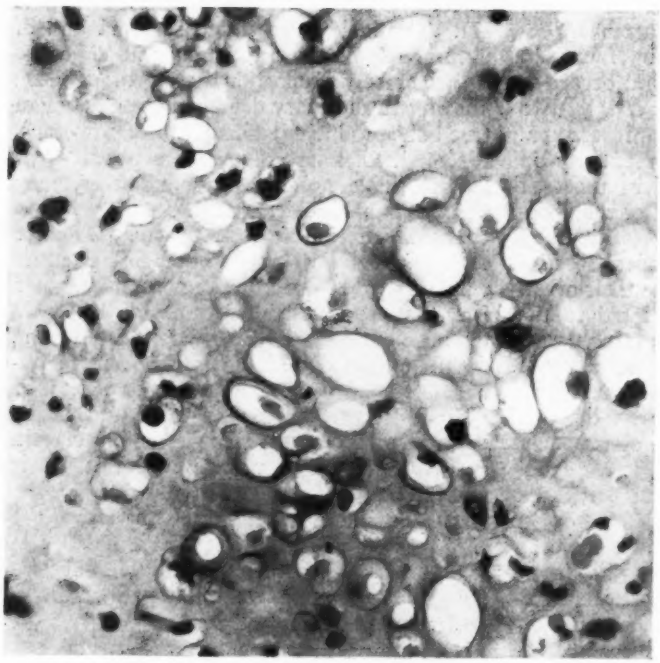

Fig. 2. Chondrosarcoma. Area of mature cartilage. B.S.R. No. 1652.

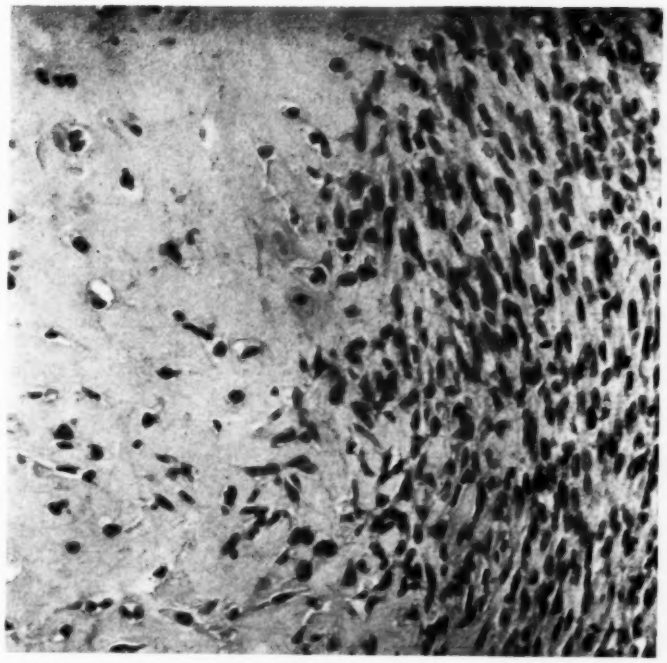

Fig. 3. Chondrosarcoma showing spindle cell morphology. B.S.R. No. 1188.

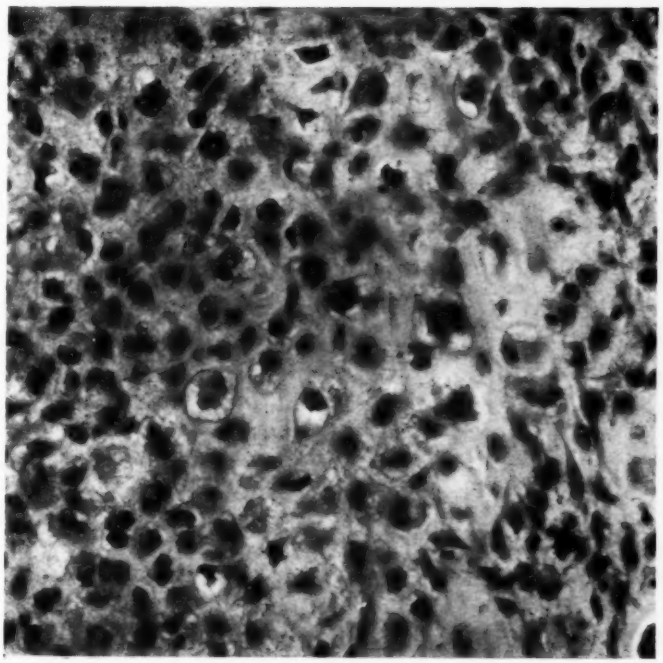

Fig. 4. Chondrosarcoma showing immature cartilage. B.S.R. No. 537.

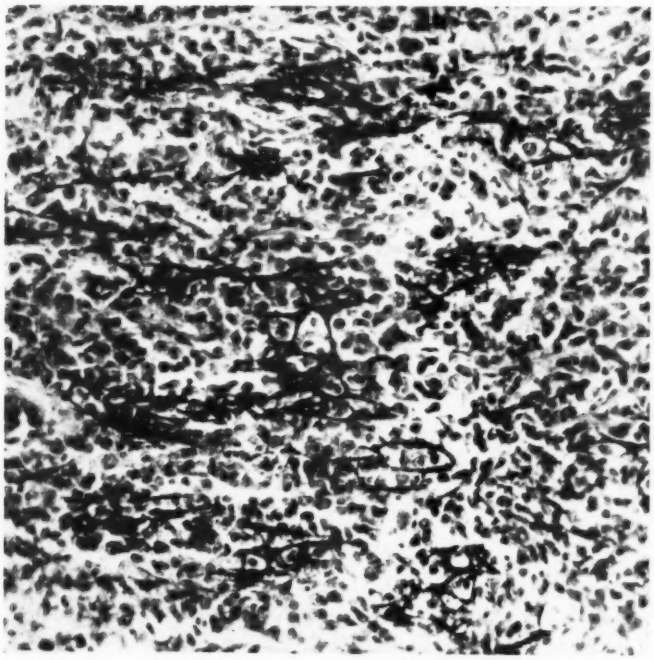

Fig. 5. Calcifying chondrosarcoma. B.S.R. No. 456.

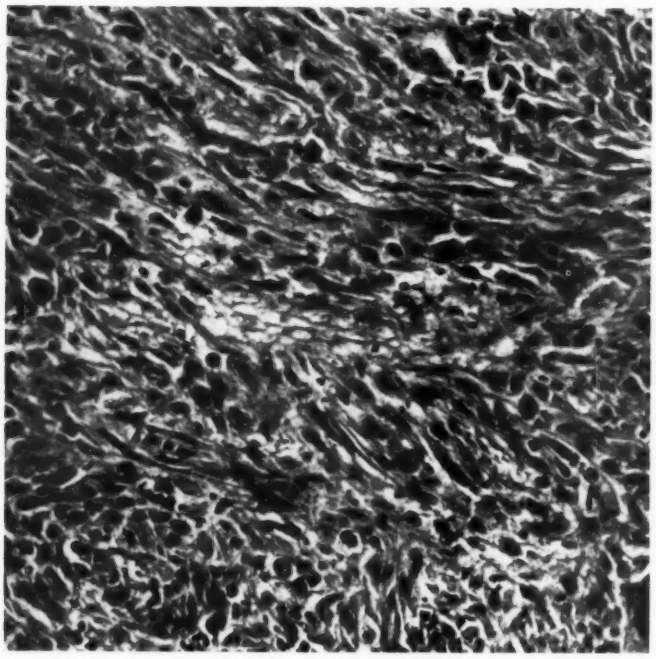

Fig. 6. Primary osseous fibrosarcoma. B.S.R. No. 1160.

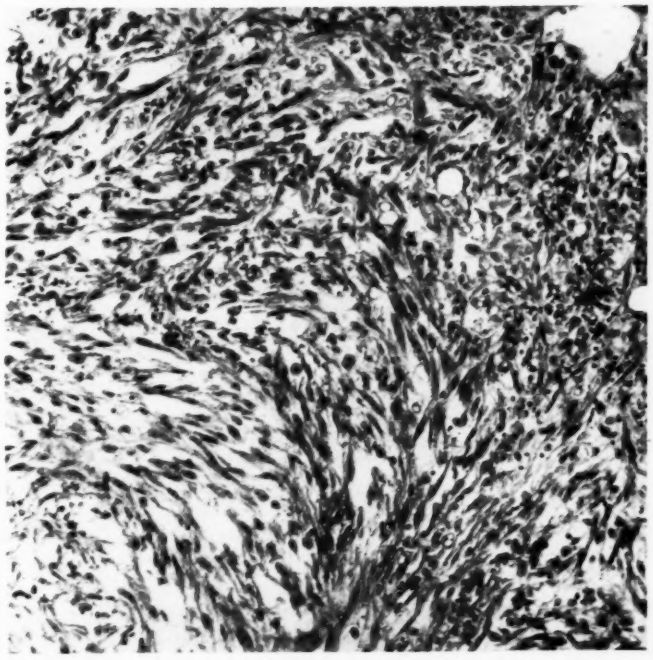

Fig. 7. Fibrosarcoma of bone showing an edematous area. B.S.R. No. 1108.

Fig. 8. Ossifying fibrosarcoma of bone. S-4508. Children's Hospital.

favorable prognostic indication. The material available did not permit an evaluation of this feature in many of the cases, but the results as shown in Table IV indicate that encapsulation is a factor of extraordinary importance

CLINICAL FEATURES

In Table IV are also shown several features of clinical interest. There is an apparent paradox in the fact that the mean period of delay from the onset of symptoms to the time of treatment is considerably greater in the cured than in the uncured cases of osteosarcoma and fibrosarcoma. Ferguson has noted this fact elsewhere, and assumed that osteogenic sarcomas have cyclic periods of active growth and relative regression as a part of their natural history, and that the favorable time for amputation is later in the disease during a period of lessened activity. We prefer to believe that the explanation lies in the inherent characteristics of the tumor, the highly malignant bone sarcomas exhibiting a more aggressive pattern of growth with early symptoms, early treatment *and* early metastases. The less rapidly growing tumors, or those in which the protective reaction of the host is more intense, fail to evoke sufficiently distressing symptoms until a later stage of the disease. One of us has demonstrated an analogous situation in mammary carcinoma. While early treatment must save certain patients, it may be assumed that curability depends more upon natural selection than on any other single factor. In this respect chondrosarcoma occupies a median position, the cured and uncured patients having come to treatment after practically identical periods of time.

The possible dangers of biopsy in bone sarcomas are not verified by the incidence in which this measure was employed in the two groups of patients. It is noteworthy that in a considerable number of the cured group the tumors had suffered much graver surgical assaults than simple biopsy. These measures included explorations, curettings, excisions or resections, performed at intervals from 1 day to 5 years prior to operation. Twenty-eight, or 23 per cent, of the 118 cured patients had suffered some such sort of surgical insult prior to radical treatment, while only 6, or 12 per cent, of the 47 uncured patients had been so mistreated. This supports the contention that the advantages of formal biopsy of bone tumors exceed the possible threat of dissemination of a bone sarcoma subjected to such a measure. This conclusion has been repeatedly emphasized by Crowell in his annual statistical analysis of Registry material.

SUMMARY

A review of 118 five year cures and 47 fatal results of osteogenic (connective tissue) sarcoma of bone is presented. The importance of primary fibrosarcoma of bone is emphasized, and the revival of the term "osteosarcoma," to signify those sarcomas characterized by bone production, is suggested. The term "osteogenic sarcoma" is best used as a generic designation for the triad of connective tissue sarcomas primary in bone, the third member of which is chondrosarcoma.

A comparative analysis of the cases of cured and uncured osteogenic sarcoma indicates that true osteosarcoma is an almost uniformly fatal form of neoplasm, accounting for but a fraction of the cures. Fibrosarcoma is a distinctly less malignant form of osteogenic sarcoma, while chondrosarcoma seems to occupy a median position, occurring in approximately equal proportions among the cured and fatal cases.

A modified classification of these tumors is presented, the object of which is to emphasize the basic division of the connective tissue sarcomas arising in bone.

Encapsulation of osteogenic sarcomas is a favorable prognostic element. The amount of matrix has not been proved to be of prognostic value.

Natural selection determines curability to a greater degree than does early treatment, for the delay in radical treatment is much greater in the cured than in the uncured neoplasms studied.

Biopsies were performed with more frequency in the cured cases than in the fatal cases.

The value of irradiation as a complementary curative agent in osteogenic sarcoma cannot be inferred from the data shown here. Actually, there is no significant statistical difference

evident as a result of irradiation, as approximately half of both the cured and uncured groups, in each of the three types of osteogenic sarcoma, were so treated. This is not to say that irradiation may not be of distinct palliative benefit in many cases.

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GASTROSTOMY FOR RETROGRADE ESOPHAGEAL DILATATION

A Leak Proof Dressing and Method of Concealing the String

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THE inconveniences due to leakage of gastric or intestinal contents from any gastrostomy or enterostomy fistula, regardless of the purpose for which it was made, need no description. When in addition, for the purposes of retrograde bouginage of the esophagus, there is present the never ending string which passes through the gastrostomy stoma into the esophagus and out the nose, with the two ends tied under the clothing, the hardships suffered are proportionately increased. Since a gastrostomy must often be endured over long periods of time, the economic and social status of the patient becomes important. Many patients are prevented from earning a living and taking their rightful place in society not because of the disease itself, but because of the inconvenience and embarrassment caused by the conspicuous string passing out of the nose and the presence of the leaking gastrostomy fistula.

The method described herein obviates these difficulties, to some extent at least, and patients upon whom it has been used have been universally grateful for their improved status.

Essentially the method suggested consists of plugging the stoma from within. For this purpose the prostatic rubber latex bag designed primarily for use after prostatectomy has been used. Any simple dilatable balloon with a catheter-like neck would probably prove satisfactory. The prostatic bag presents certain distinct advantages, however, especially in gastrostomies, in that the drainage catheter which passes through it can be used for feeding. The bag illustrated in Figure 1 consists of a dilatable bag, *a*, through which the large catheter, *b*, passes; the bag is built around it but the two do not communicate by any orifice. The catheter projects distally for an inch or more beyond the bag, with its orifice placed on the side at this distal end. Alongside the catheter is a second tube, *c*, considerably smaller in caliber, which terminates within the balloon or bag itself. This is used for dilating the bag. The catheter and smaller tube are enclosed in a common sheath. For gastrostomies a bag with a potential capacity of 75 cubic centimeters is used.

The technique of application is as follows: The catheter is inserted into the gastrostomy wound to a depth at which the bag lies well within the lumen of the stomach. Twenty or 25 cubic centimeters of water or saline are instilled into the bag through the smaller tube, *c*, by means of a Triumph syringe (Fig. 2). The tube is then temporarily occluded by squeezing it between the thumb and forefinger, and the bag is withdrawn until it contacts the anterior wall of the stomach, when rather forceful traction is exerted upon it to determine if the bag has been dilated sufficiently to occlude the gastrostomy orifice completely and can resist traction without being extruded. If not, additional quantities of fluid are added as seem indi-

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The opinions or assertions contained herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

Fig. 1. The bag consists of *a*, dilatable bag; *b*, catheter; *c*, small caliber tube which terminates in balloon or bag itself.

Fig. 2. Same as Figure 1 with bag, *a*, dilated and *c*, smaller tube doubled over and tied.

cated, until a state of filling which will accomplish this has been reached. The tube, *c*, is then doubled over and tied off, and for this purpose a length of woven tape is preferred rather than the rubber band shown in the illustration. When this has been accomplished, the bag, for the time being can be allowed to fall back into the stomach with the catheter protruding.

A single 4 by 4 surgical gauze dressing, which has previously been split lengthwise, is placed over the wound, the catheter is inserted into the split, and the gauze dressing is then pinned below it. It has been found advantageous as a counterbrace to utilize a rounded piece of tin, thin plastic, or wood such as yucca board, or simply a semirigid piece of adhesive over cardboard, measuring about 2.5 inches in diameter. A hole large enough to admit the catheter easily is made in the center of it, the catheter is then threaded through the hole, and the disc is lowered to lie on the gauze (Fig. 3).

A spring clip such as is illustrated, or any reasonable modification of it, is then threaded over the catheter which is brought through the expanded end of the clip. While one hand holds the dressing down on the abdominal wall the other withdraws the catheter as far as is possible, so that the filled balloon comes to lie snugly against the internal aspect of the abdominal wall with the neck of the balloon protruding somewhat into the gastrostomy stoma. While relatively strong traction is maintained on the catheter, the hand holding the dressing is now freed and used to spread the clip applying it across the catheter near its junction with the neck of the bag and snugly approximated to the metal disc. The catheter is then curved to lie in any convenient position on the chest or abdominal wall and made fast with two or three adhesive strips. This completes the dressing, which can be fully applied in 2 or 3 minutes (Fig. 4). The string attached to the clip in this illustration can be disregarded except when the gastrostomy is for purposes of retrograde dilatation of the esophagus. Its use in this regard will be discussed later.

When feedings are necessary, the patient himself compresses the spring clip, allowing the catheter to fall into its dilated ring and, with a Triumph syringe or other means, instills the feeding through the catheter. When this has been accomplished he then pulls the catheter taut, so that the bag once again comes to lie snugly against the

abdominal wall, and reapplies the clip against the disc. It is of course not necessary to remove the dilating fluid from the bag, or to remove any other part of the dressing. If conveniently located upon the abdominal wall or chest it is not even necessary to remove the adhesive strips holding the catheter. The split gauze is changed once daily, during any one of the feedings. Air is not satisfactory for filling the balloon, and after a fair trial it has been discarded entirely in favor of the fluid.

When properly applied this device is absolutely leak-proof, a "stopper" having been inserted into the stoma from the interior of the stomach. When intragastric pressure is increased, the "stopper" fits all the more tightly. No gastric content or gas whatsoever escapes. The gauze when removed may have a small negligible spot of gastric secretion (but not food) upon it, due to the fact that a margin of gastric mucosa may protrude into the stoma and lie against the gauze, so that the secretion from this very small area stains it a little. If no gastric mucosa protrudes, even this minimum staining does not occur.

No protective ointment next to the skin is required, since I have not seen even the most mild degree of dermatitis, because of the fact that the skin surrounding the stoma is not bathed in gastric juice.

A balloon having a slightly pear-shaped neck seems theoretically to adapt itself better to the contour required. A completely rounded balloon, which might be necessary as a makeshift has not been tried. It might prove equally effective however. It would seem that if the bag were made of sufficiently soft rubber, traction upon the catheter prior to fixing it *in situ* with the clip would naturally result in an entirely round balloon being drawn out a little at this point, thus adapting itself automatically to the shape required for maximum efficiency.

To remove the balloon from the abdominal cavity, it is simply necessary that the tape be removed from the smaller tube, *c*, which is held over a basin, and gentle continued traction against the abdominal wall thereupon results in the bag emptying itself, after which it can be easily withdrawn. If preferred, the fluid can of course be aspirated from the bag by use of a suction syringe.

The patient illustrated wore the bag for almost a year. During this period it was necessary to replace the bag with a new one about every fifth week, since after this time the action of the gastric juice seemed to destroy the elasticity of the rubber. For the first day or two the patient said he was conscious of the presence of the bag, although it occasioned no pain or serious discomfort. After

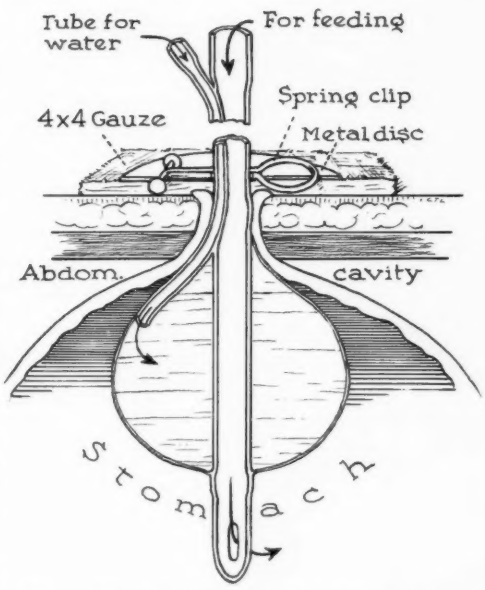

Fig. 3. Schematic drawing to illustrate sagittal section through stomach, site of gastrostomy, and dilated occluding bag *in situ*.

that he hardly realized he was wearing it, and was able to carry out his work as a musician playing a brass wind instrument. Actually the idea of the bag developed from his complaining that when he attempted to play this instrument with his original conventional dressing, the increased abdominal pressure required by efforts of blowing into the horn resulted in such a profuse escape of gas and fluid that he was forced to discontinue playing even at home, except when his stomach was entirely empty. After the use of the bag was instituted he was able to resume his work professionally and was entirely free of all such complications.

No pressure atrophy of the area has been noted in any case in which the bag has been used.

Besides its use in gastrostomies, this method has been tried in enterostomies and colostomies performed by others. In these cases smaller bags were used. One ambulatory patient who had had a colostomy for several years and who irrigated the colon once a day through a tortuous tract, tried the bag for only 24 hours and preferred to be without it since it created a sense of fullness. In others it proved entirely satisfactory. Dressings remained dry and clean; there was no odor of intestinal contents and no skin irritation occurred.

Fig. 4. Patient with device applied.

For use in the colon or small bowel it is a decided advantage to use a smaller bag of a size that does not fill the lumen of the bowel in order to avoid the initiation of peristaltic waves. A flattened balloon built in the shape of a disc rather than an ovoid or ball would seem the most desirable for use in the intestine, but the advent of the war prevented its experimental manufacture. Of course, when used for this purpose in the bowel rather than in the stomach, it is not necessary that a catheter pass through the balloon. A simple rubber bag, with a single inlet tube, is sufficient. It can be removed periodically for irrigation of the intestine. There may be some advantage in weaning the patient to the use of the bag, allowing him to wear it at first for a few hours only.

My personal experience with the use of the dressing in enterostomies and colostomies is more limited than for gastrostomies, and I presume that frequently others will have unsatisfactory experiences such as the one I have outlined. Each case is therefore an experiment unto itself and the method will prove successful in some and not in others. It has proved universally successful, however, in gastrostomies and for this purpose at least the dressing can be wholeheartedly recommended without reservation.

Under the present circumstances, since it is difficult to obtain stock items, especially of rubber, a bag can be improvised from segments of a rubber glove or two thicknesses of condom rubber cemented to a length of small bore rubber tubing.

Opportunity has not yet presented itself of trying the method on tiny fistulas, all the cases reported having been large surgical enterostomies. However, it is my opinion that a small enough bag could be made so that it could be introduced into most tracts.

The advantages of preventing leakage of gastric or intestinal contents through a surgical stoma need no emphasis; it is sufficient to say that patients never seem quite so grateful as are those who have been successfully converted from the old type dressing to the new, and this applies as well to the nursing staff caring for them.

While the bag described is intended for use in gastrostomies or enterostomies created for any purpose, a further nicety should be mentioned in regard to the care of those upon whom gastrostomy has been performed for the purpose of retrograde dilation of the esophagus and who constantly wear the string required for use with the Gabriel Tucker retrograde bougies. This string remains *in situ*, within the esophagus at all times, emerging at one end from the gastrostomic fistula and at the other end from the nose, being tied on the outside and forming a never-ending loop. It acts as the guide string by means of which the bougie is drawn upward through the esophagus from below. The presence of the string is not entirely pleasant under any circumstances, but in the adult who mingles in society and attempts to earn a living where he is exposed to the gaze of others, it in itself is a constant source of embarrassment so great that many follow almost a hermit's existence.

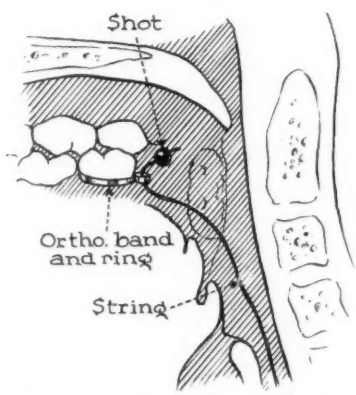

Fig. 5. Schematic drawing showing method of concealing string by fastening to molar when gastrostomy is performed to permit retrograde dilatation of the esophagus.

The method of attachment which has been successfully used does not do away with the string, the maintenance of which in the esophagus is necessary for the treatments. It is simply a means of doing away with that portion of it which emerges from the nose; which, however, represents a distinct advantage, at least from the standpoint of social contact and economic activities.

The patient is sent to an orthodontist who places a modified orthodontic band around a lower tooth. Fortunately, in the patient illustrated the last lower molars on each side were missing. The band was therefore placed around the second lower molar. On the posterior aspect of the band there had been built, prior to installation, a small gold circular loop placed horizontally, which came to occupy a portion of the space previously occupied by the third molar. The string is threaded through this loop from below and brought out through the mouth. A split, large sized buckshot with a diameter greater than that of the gold loop is placed on the string with the latter lying within the split which was then squeezed together over the string by means of a small pliers or old heavy hemostat. In this fashion the shot was fixed to the string, and the excess of the latter cut off nearly flush with the shot. Traction is then exerted upon the string from the end emerging through the gastrostomy so that the shot is pulled into the mouth until it contacts the loop on the orthodontic band, coming to rest on its superior aspect (Fig. 5). It can of course then go no further because the shot will not pass through the loop which is of smaller diameter. The free end of the string emerging from the gastrostomy is then tied to the spring clip which fixes the balloon, leaving plenty of excess as shown in Figure 4. The string is worn in this fashion during the entire period between treatments. No string, of course, emerges from the nose and it is impossible to tell by looking at the patient that he is wearing any such appliance.

The second molar need not necessarily be used, but the tooth selected should be a lower one, and the position of the band and loop can be varied according to the ingenuity of the dentist and the dental status of the patient.

When the dilatations are to be carried out, the string is untied at the spring clip on the abdomen, and by means of a hook or small pillar retractor introduced into the pharynx, a loop of string is pulled forward out of the mouth and cut. The distal end is used for the dilatation, as is ordinarily done. The proximal short length still attached to the shot is removed by grasping the shot with a hemostat and extracting it. It is then discarded. Following the dilatation the free end of the string protruding from the mouth is again threaded through the orthodontic loop from below and fixed with the shot as before. It is important during these manipulations to be sure that the length of string protruding from the gastrostomy is sufficiently long so that the end is not withdrawn into the stomach and lost. Extra lengths can be tied on for the purpose.

The plugging of the gastrostomy from within and the elimination of the string protruding from the nose have given most satisfactory results, serving to rehabilitate, socially and often economically, those upon whom it has been used.

THE ARTERIAL BLOOD SUPPLY OF THE PANCREAS

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An artery supplying the pancreas was first pictured and briefly described by Vesalius in 1564. The supply was more completely described by Winslow, Haller, and Bell. Modern anatomy texts have followed the works of Verneuil and other anatomists of the early 19th century, leaving unused the more accurate descriptions of the earlier and subsequent investigators. Since then, Sappey, Wiart, Rio Branco, Brun, Testut, Lipshutz, Romodanowskaja, Adachi, Petrén, Wharton, and Ziegler have contributed substantially to our understanding of the vessels supplying the pancreas. Many others have written articles of interest on this subject, but each of the men named has contributed at least one new and important finding which bears on this subject. The reader is especially referred to Petrén's monograph on the arterial and venous supply of the duodenum and head of the pancreas (7). The works of Romodanowskaja and Ziegler are also of particular importance.

For the surgeon, any description of the blood supply to the pancreas without some mention of the vessels supplying the duodenum is incomplete, since the relationship of the two organs is most intimate. A concise, accurate description of the arterial supply to the first part of the duodenum is given by Wilkie.

Dissections were made of arterially embalmed and injected cadavers in the anatomy laboratories of the University of Oregon Medical School and of specimens from autopsies which were injected with a gelatin color mass and fixed in 10 per cent formalin solution. In all, 50 dissections were performed. Percentages quoted herein are in some instances computed from slightly less than the total number because of difficulties of dissection encountered in parts of the region dissected. Unless specified, percentages given are of the writer's series of cases. The vascular pattern described has been limited to the most constant vessels and those of greatest surgical significance.

Typically (Fig. 1) the pancreas is supplied by two arteries from the gastroduodenal, two from the superior mesenteric, and one from either the splenic, hepatic, or celiac arteries. In addition to these a variable number of small arteries arise from the splenic, gastroduodenal, and hepatic. The larger vessels arising from the gastroduodenal artery are the *superior pancreaticoduodenal arteries* (right pancreaticoduodenal of some authors). These are two in number, an *anterior* and a *posterior*. They anastomose with corresponding *anterior* and *posterior inferior pancreaticoduodenal arteries* (left pancreaticoduodenal) from the superior mesenteric (Fig. 1). These vessels form two arterial arcades, one on the posterior surface of the head of the pancreas, the other, except for its lowermost part, on the anterior surface. They are respectively the *posterior* and the *anterior arcades* of the pancreas. The two inferior pancreaticoduodenal arteries usually arise in a common trunk from the superior mesenteric, the *common inferior pancreaticoduodenal artery*. The *superior pancreatic artery* is the least constant of any of the large arteries to the pancreas. When present, it arises from the splenic, hepatic, or directly from the celiac arteries. In addition to the arteries mentioned, an *inferior pancreatic artery*, which passes along the inferior margin of the body to the tail, may take origin from the superior mesenteric, the anterior superior pancreaticoduodenal, the inferior pancreaticoduodenal, or the superior pancreatic artery.

The pancreaticoduodenal arteries are usually at least 2 millimeters in diameter, the superior nearly always being larger than the inferior. The superior pancreatic artery is most commonly 1.5 millimeters and the inferior pancreatic 1.0 to 1.5 millimeters in diameter. All other vessels mentioned are usually 1.0 to 1.5 millimeters in diameter.

The *gastroduodenal artery* (Figs. 1, 2, 5, 6) arises from the hepatic just dorsal and slightly superior to the junction of the pylorus and the duodenum. Whereas the hepatic passes upward in the hepatoduodenal ligament, medial to the common duct and anterior to the portal vein, the gastroduodenal courses downward, medial to the common duct and dorsal to the first part of the duodenum to terminate at its lower border by dividing into the right gastroepiploic and anterior superior pancreaticoduodenal arteries. As the gastroduodenal passes dorsal to the superior margin of the duodenum, it gives off the posterior superior pancreaticoduodenal artery. Two smaller branches are given off to the first part of the

From the Departments of Anatomy and Surgery, University of Oregon Medical School. Prepared under the direction of Dr. Robert S. Dow and Dr. John A. Gius.

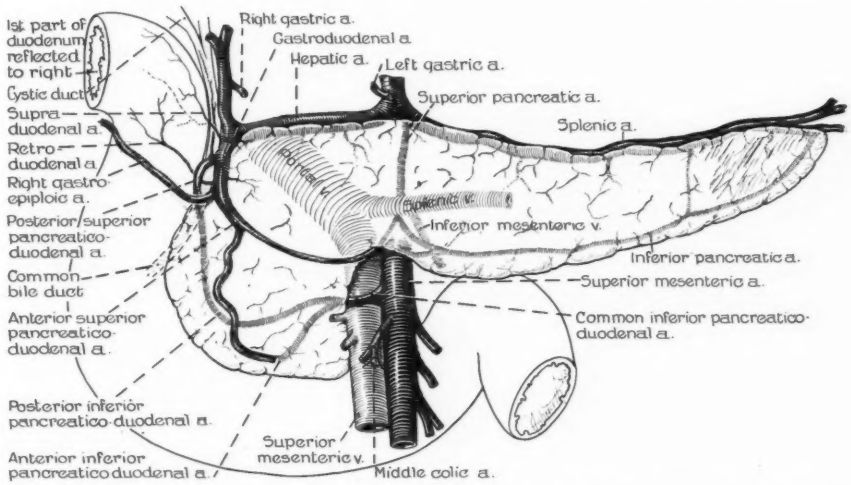

Fig. 1. Diagrammatic representation of the typical arterial supply of the pancreas. Anterior aspect.

duodenum (Figs. 1, 5): the *supraduodenal artery* to the superior wall and most of the anterior surface, and the *retroduodenal artery* (Fig. 1) arising one-half inch above the bifurcation of the gastroduodenal and supplying the lower two-thirds of the posterior wall, sometimes extending as far as the second part. The remainder of the first part of the duodenum is supplied by branches from the pyloric, the right gastroepiploic, and the superior pancreaticoduodenal arteries. A few variable and unnamed branches are usually given to the head of the pancreas.

The *posterior superior pancreaticoduodenal artery* (Figs. 1, 3, 4, 5, 6) (superior right pancreaticoduodenal) is a surgically important artery, 2 millimeters in diameter, which has escaped mention in modern textbooks of anatomy in spite of its occurrence in 96 per cent of the 50 cases dissected. Edwards found this artery in 97 per cent of 100 cadavers but mistook it for the retroduodenal artery described by Wilkie. It takes origin from the right dorsal side of the gastroduodenal and in 86 per cent of cases (Petrén) passes to the right and inferiorly across the anterior surface of the common bile duct. It then curves downward from the right side of the duct toward the left, crossing dorsal to the intrapancreatic part. Thus, the common duct passes through an arterial loop formed by this artery (Figs. 1, 4, 5). Petrén found that in 14 per cent of cases the gastroduodenal artery lies directly anterior to the common duct where this artery comes off. In these cases the anterior part of the loop is absent (Fig. 3). It passes downward in an arc to anastomose with the posterior inferior pancreaticoduodenal artery. As it loops over the common bile duct, it nearly always contributes small branches to it (Figs. 1, 5). Commonly one of these extends up the wall of the common and cystic ducts (Fig. 5), sometimes being developed to such a degree as to form an accessory cystic artery. Section and ligation or transplantation of the common duct might lead to necrosis by interfering with these blood vessels. This may explain the leakage of bile common after these procedures.

The posterior arcade is usually situated cephalad to the anterior arcade. The fine branches of the posterior arcade anastomose with each other, forming secondary and tertiary arcades more frequently than do those of the anterior arcade (Fig. 4). Short branches from it supply pancreatic tissue; longer, more superficial branches supply the duodenum.

The *anterior superior pancreaticoduodenal artery* (superior pancreaticoduodenal, right inferior pancreaticoduodenal) arises as a terminal branch of the gastroduodenal in 100 per cent of the cases examined (Figs. 1, 2, 6). It comes off just above the lower wall of the first part of the duodenum. In 76 per cent of these cases the arcade passes directly downward and then curves slightly to the left over the anterior surface of the head of the pancreas, many times being partially imbedded in it but nearly always visible from in front (Fig. 2). This first part of its course lies 1.5 to 2 centimeters away from the anterior groove between

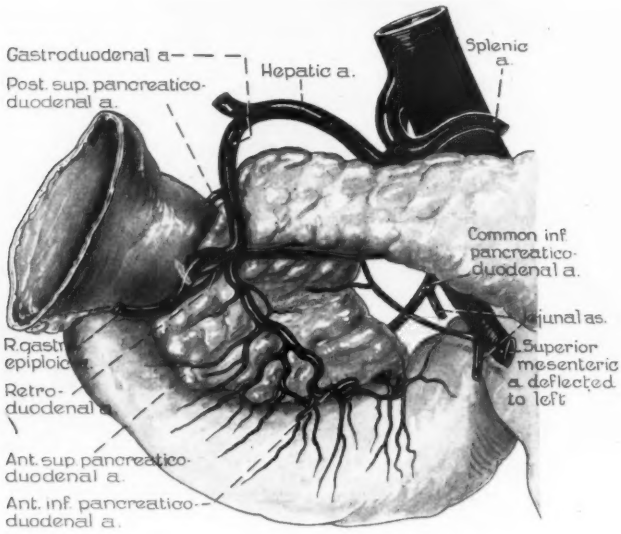

Fig. 2. The most common arrangement of the anterior pancreatic arcade. Anterior aspect with pylorus and first part of duodenum reflected to the right. (Modified from Petrén.)

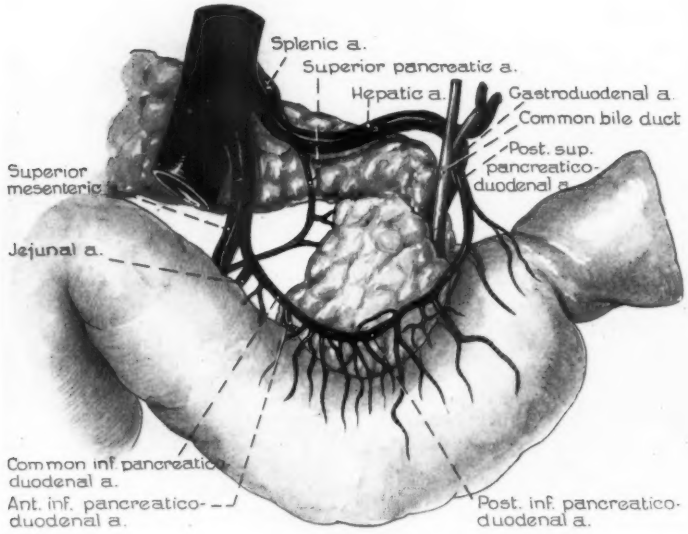

Fig. 3. Posterior aspect of the specimen in Figure 2 showing relations present in 14 per cent of cases. The gastroduodenal artery lies directly anterior to the common bile duct. (Modified from Petrén.)

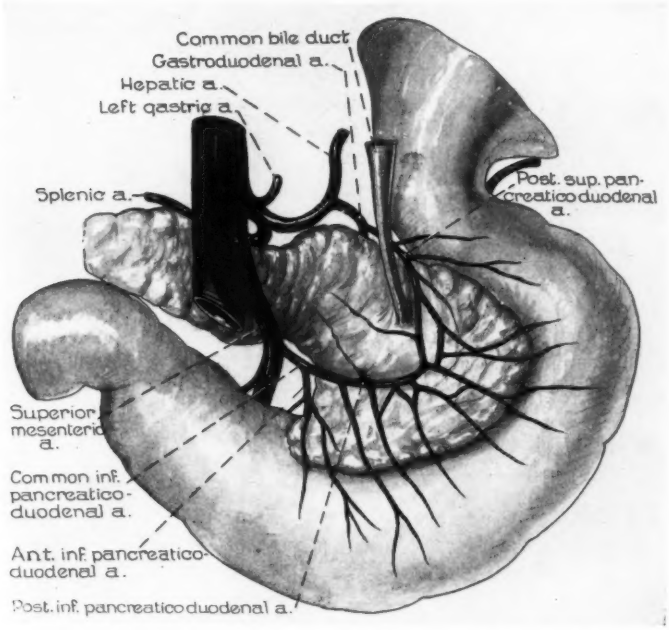

Fig. 4. The most common arrangement of the posterior pancreatic arcade. Posterior aspect with pylorus and first part of duodenum reflected to the right. (Modified from Petrén.)

pancreas and duodenum. As it descends, it approaches the groove more closely until at the junction of the horizontal and the ascending parts of the duodenum it reaches the groove. It then bends sharply around the inferior margin of the pancreas, or passes through it. Finally it passes dorsally and up ward to the left to lie in its last fifth on the posterior surface of the head of the pancreas, or within the substance of the gland. That portion of the arcade lying on the anterior surface of the gland is often quite tortuous. In 24 per cent of cases the anterior arcade lies throughout its course on the anterior surface of the head of the pancreas. In these cases, although the arcade approaches the groove between gland and duodenum, it never attains it.

The *anterior* and *posterior inferior pancreaticoduodenal arteries* (Figs. 1, 2, 3, 4, 6) may arise either in a common trunk (62 per cent) or separately (38 per cent) from the superior mesenteric (60 per cent), the first jejunal (26 per cent), or the middle colic artery (14 per cent). They usually (in 64 per cent) arise posteriorly from the superior mesenteric or jejunal arteries. In 36 per cent of cases they arise from the right side, the anterior surface, or the left side of the superior mesenteric artery. Nearly always those arising from a jejunal artery come off dorsally. The origin of these vessels is usually at the lower margin of the neck of the pancreas, but they may come off high behind the pancreas. The duodenojejunal flexure is supplied mainly by branches from one of the inferior pancreaticoduodenal arteries, the first jejunal making a minor contribution to it. In cases in which these vessels may be destroyed it is suggested that the surgeon excise the proximal 1 or 2 inches of the jejunum.

The *inferior pancreatic artery* (Fig. 1) is constant according to Wharton, who found it present in 100 per cent of 30 dissections and corrosion preparations. It may take origin from the superior mesenteric, the anterior superior pancreaticoduodenal, the inferior pancreaticoduodenal, or the superior pancreatic artery and usually receives connections from two or more of these. It passes from the right toward the tail imbedded in the dorsal surface of the body of the pancreas and lies entirely within 3 centimeters of the inferior margin of the gland. It receives anastomoses from pancreatic branches of the splenic artery.

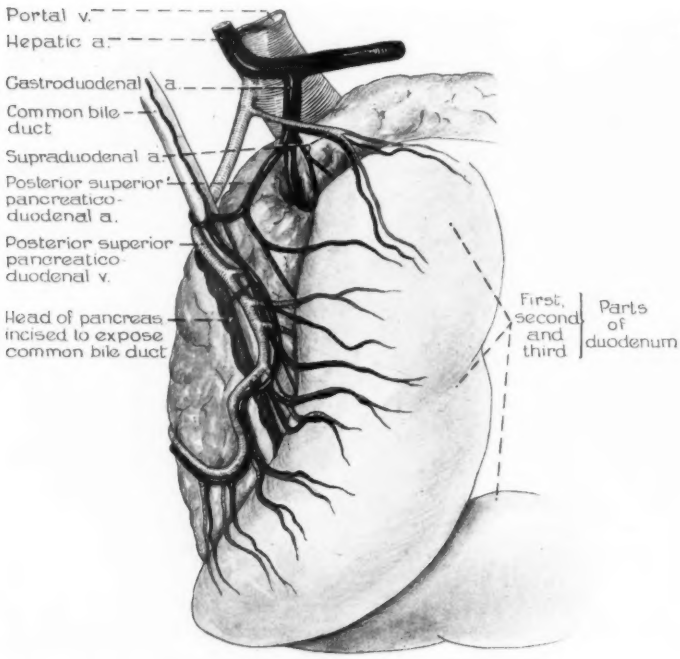

Fig. 5. Vascular distribution about the common bile duct as viewed from the right when the duodenum and attached pancreas are reflected medially. (Modified from Rio Branco.)

The *superior pancreatic artery* (Figs. 1, 3, 6) (great superior pancreatic—Haller)[1] is present in 54 per cent of cases and is quite variable in size. Although usually about 1.5 millimeters in diameter, it varies from 1 millimeter to nearly 1 centimeter. This vessel arises from the first 2 centimeters of the splenic or hepatic artery or from the celiac axis. It may give origin to the middle colic artery (Fig. 6) (4 per cent) or may anastomose with it (4 per cent). This artery passes dorsal to the neck or body of the pancreas and the splenic vein. It divides into a branch which passes to the anterior surface of the head to anastomose with a fairly constant branch of the anterior superior pancreaticoduodenal artery (Figs. 1, 2, 6). The other branch courses to the left where it usually communicates with the inferior pancreatic artery and may give origin to it. The superior pancreatic artery is not described in any of the standard textbooks.

The other pancreatic branches (Figs. 1, 6) (lesser pancreatics) from the splenic artery are usually quite small, but occasionally one may attain 2 millimeters in diameter. They immediately ramify in the substance of the gland, anastomosing with one another and with the inferior and superior pancreatic arteries. They vary in number from two to nine and are always present.

Pancreatic branches of the gastroduodenal (Fig. 1) are common but variable. They occur in 62 per cent of cases. Most of them tend to occur near the termination of this artery.

Branches of the hepatic supplying the pancreas (Fig. 1) are inconstant and variable. Vessels 1 millimeter or larger in diameter are present in only 10 per cent of cases. They vary in number from one to four, and tend to be present when the hepatic is unusually long or imbedded in the pancreas.

The middle colic artery may have several important relations to the pancreas. It may arise high on the superior mesenteric and be in contact with the pancreas for a short distance. In one case observed it passed through the head of the pancreas, having its major bifurcation while im-

[1] This is not to be confused with the "great pancreatic" of some textbooks, which is omitted in this discussion since it is rarely found as described.

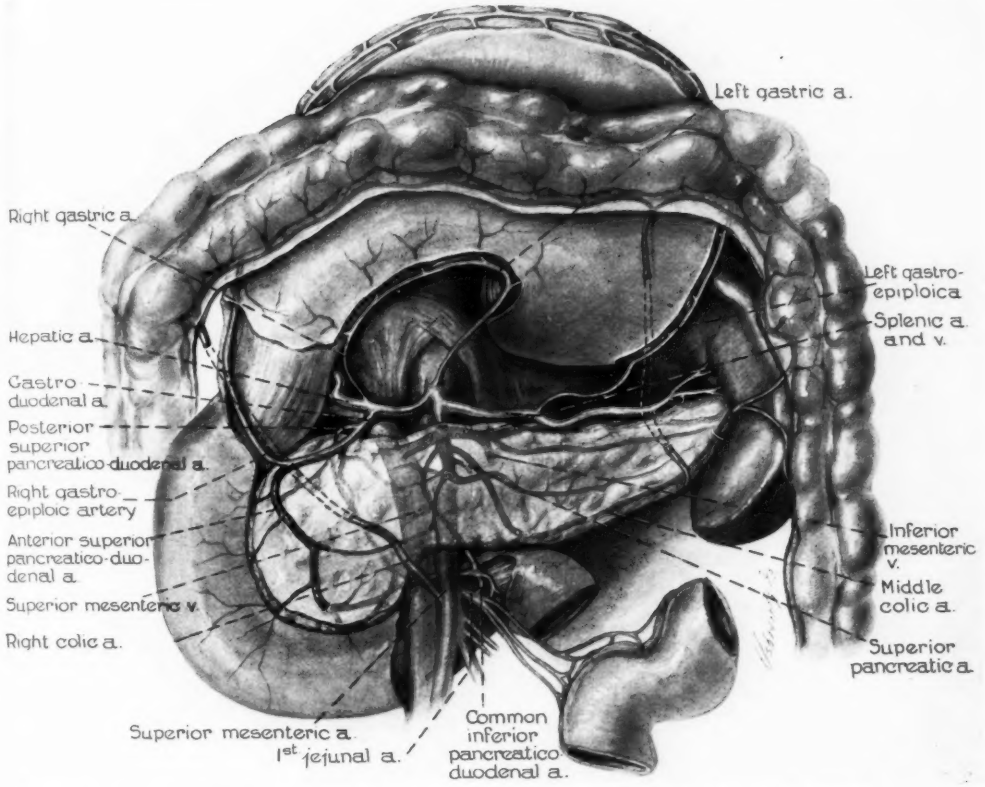

Fig. 6. Specimen in which the middle colic artery takes origin from the superior pancreatic. The transverse colon and stomach are reflected upward. Note that the right colic artery passes directly to the hepatic flexure of the colon and that the middle colic artery passes to the splenic flexure.

bedded in the gland. The middle colic may divide near its origin into two or three fair-sized vessels, one of which, en route to the splenic flexure, may lie imbedded in the pancreas along its inferior margin or in the posterior capsule of the gland. Figure 6 shows one of two cases observed in which the middle colic artery took its origin from the superior pancreatic. Ziegler describes two cases in which the middle colic artery took its origin from the gastroduodenal.

An anomalous hepatic artery arises from the superior mesenteric in 10 per cent of cases (8 per cent right hepatic artery, 2 per cent an accessory hepatic). When present, it passes dorsal to the head of the pancreas into the hepatoduodenal ligament, often lying dorsal to the common bile duct. The cystic artery has a similar origin and course in 4 per cent of cases. These anomalous hepatic and cystic arteries always give origin to large branches which supply the posterior surface of the gland and contribute to the posterior arcade.

The relationship of the arteries to the veins is fairly constant. Every artery here described has a concomitant vein. According to the writer's observations, as well as Petrén's, the veins usually lie nearer the surface of the gland than the arteries. The anterior superior pancreaticoduodenal vein drains constantly into the right gastroepiploic vein, which is a tributary of the superior mesenteric. The posterior superior pancreaticoduodenal vein almost always drains directly into the portal vein (Fig. 5). The lower veins empty directly into the superior mesenteric or one of its tributaries. The posterior inferior pancreaticoduodenal vein may empty into the inferior

mesenteric. The splenic vein, which is sometimes imbedded in the gland, receives several veins from the body and tail.

SUMMARY AND CONCLUSIONS

A brief review of the literature on the circulation of the pancreas is presented. Observations on the arterial circulation of the pancreas in 50 cases are reported. The arterial supply of the pancreas though variable follows a fairly constant pattern. The anterior and posterior arcades lie on the respective surfaces of the head of the gland. Arteries supplying the pancreas found in this study are:

- Anterior superior pancreaticoduodenal in 100 per cent of cases } form the anterior arcade
- Anterior inferior pancreaticoduodenal in 100 per cent } form the anterior arcade
- Posterior superior pancreaticoduodenal in 96 per cent } form the posterior arcade
- Posterior inferior pancreaticoduodenal in 100 per cent } form the posterior arcade
- Inferior pancreatic in 100 per cent (Wharton)
- Superior pancreatic in 54 per cent
- Pancreatic branches of the splenic in 100 per cent
- Pancreatic branches of the gastroduodenal in 62 per cent
- Pancreatic branches of the hepatic in 10 per cent.

The vessels supplying the first part of the duodenum are: the supraduodenal, the retroduodenal, and branches from the pyloric, the right gastroepiploic, and the superior pancreaticoduodenal arteries.

The arterial loop formed by the posterior superior pancreaticoduodenal artery around the common bile duct is described. Branches from this vessel supply the common duct. It is suggested that damage to this blood supply may result in leakage of bile following ligation or transplantation of the common duct.

The veins of the pancreas follow the general course of the arteries but lie superficial to them.

Attention is directed to the posterior superior pancreaticoduodenal, the inferior pancreatic, and the superior pancreatic arteries, which, although of important size and relatively constant occurrence, are uniformly neglected in descriptions of the pancreatic circulation found in standard anatomy textbooks.

Since the duodenojejunal flexure is supplied mainly by branches from one of the inferior pancreaticoduodenal arteries, it is recommended that in procedures which might interrupt these vessels the proximal 1 or 2 inches of the jejunum be excised.

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THE EFFECT OF ESTROGENIC SUBSTANCE UPON UTERINE MOTILITY DURING LABOR

A Study of 42 Patients with the Lóránd Tocograph

DOUGLAS P. MURPHY, M.D., F.A.C.S., Philadelphia, Pennsylvania

IN a previous report (1) we described the effect of estrogenic substance upon uterine motility during late pregnancy. The uterus reacted only after the 28th week of gestation; the incidence of response increased progressively as pregnancy advanced; the drug influenced both the tone of the uterus and the intermittent contractions, but the occurrence, the nature, and the degree of the responses were unpredictable.

The present study concerns the effect of estrogenic substance upon uterine motility during labor and was undertaken in order to discover how it influences activity at this time.

MATERIALS AND METHODS

Patients on the ward service of the Hospital of the University of Pennsylvania acted as subjects. Observations were conducted between September 9, 1942, and January 12, 1943. Uterine contractility was registered with a Lóránd tocograph. Estrogenic substance, in the form of a-estradiol dissolved in sesame oil, was administered intramuscularly. Observations were made early in the first stage of labor when possible. The uterine contraction pattern was registered continuously for an hour. The estrogenic material was given 15 minutes after the tocographic record was begun.

RESULTS

Of 42 patients who were treated, 17 gave a uterine reaction. Ten experienced an increase in tone. Seven registered no increase in tone but did exhibit slight alterations in the character of their intermittent contractions.

Representative examples of increases in tone are illustrated in Figures 1 to 5b inclusive. The reaction time averaged 19 minutes and 48 seconds ± 9 minutes. The rises in tone were abrupt in some patients (Figs. 1 and 2) and less so in others (Figs. 3 and 4). In all patients the increase in tone after treatment persisted throughout observation.

From the Gynecean Hospital Institute of Gynecologic Research, Department of Obstetrics and Gynecology, University of Pennsylvania. Aided in part by a grant from Ciba Pharmaceutical Products, Inc.

One patient who reacted with an increase in tone received a second treatment after an interval of 4 hours and again reacted in a similar manner, as shown in Figures 5a and 5b.

The estrogenic substance altered the intermittent contractions of only 7 patients. One experienced a slight increase in the frequency of her contractions; 3 exhibited an increase in both the frequency and the strength; 2 showed an increase in the rhythmicity; and 1 had an increase in the strength and duration. The effects of the drug upon these 7 patients were so minimal that the reactions were not considered significant.

EVALUATION OF STUDY

The findings of our previous study (1), together with those of the present one, indicate that estrogenic substance influences uterine motility. When administered during labor it appears to effect primarily the tone of the uterus.

Our chief interest in the study of uterine activity during pregnancy and labor centers around the discovery of some means whereby slow labor may be expedited. In two earlier studies we noted that the tone of the uterus tends to increase during late pregnancy (2), and likewise during labor (3). In recording the contraction pattern of patients who experienced primary inertia, we found that they usually exhibited uterine contractions small in magnitude and variable in their other characteristics (4). In addition such patients usually experienced a low uterine tone.

Since our observations indicate that a certain increase in tone is to be expected during labor, a drug which raises uterine tone ought to have value in the treatment of patients suffering from primary inertia. The observations forming the basis for this report were made upon patients experiencing normal labors. It is possible that estrogenic substance might raise the uterine tone of such patients but have no appreciable effect upon patients suffering from primary inertia. As primary inertia continues to be a major obstetrical problem, it would seem of value to study further the effect of estrogenic substance upon uterine motility. Such investigations are now in progress.

Fig. 1. Patient B. C., tracing 2,447. Observation of uterine motility made during first stage of labor, lasting 73 minutes and 48 seconds. At left-hand arrow 0.354 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 12 minutes and 54 seconds later, note increase in tone, as indicated by the higher level of the trough of the preceding wave, above the base line.

Fig. 2. Patient D. S., tracing 2,380. Observation of uterine motility during first stage of labor, lasting 66 minutes and 36 seconds. At left-hand arrow 0.708 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 18 minutes and 36 seconds later, note increase in tone.

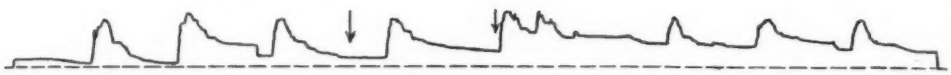

Fig. 3. Patient D. S., tracing 2,267. Observation of uterine motility during first stage of labor, lasting 83 minutes and 6 seconds. At left-hand arrow 0.354 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 15 minutes and 54 seconds later, note increase in tone.

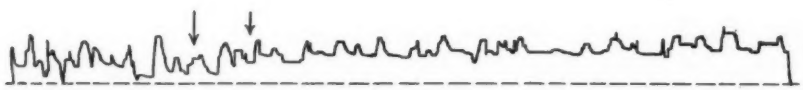

Fig. 4. Patient L. W., tracing 2,318. Observation of uterine motility made during first stage of labor, lasting 69 minutes and 54 seconds. At left-hand arrow 0.354 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 6 minutes and 54 seconds later, note increase in tone.

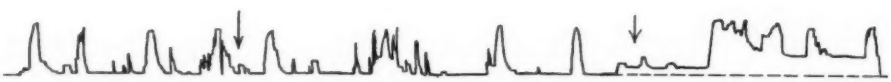

Fig. 5a. Patient L. C., tracing 2,304. Observation of uterine motility made during first stage of labor, lasting 76 minutes and 48 seconds. At left-hand arrow 0.354 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 35 minutes and 42 seconds later, note increase in tone.

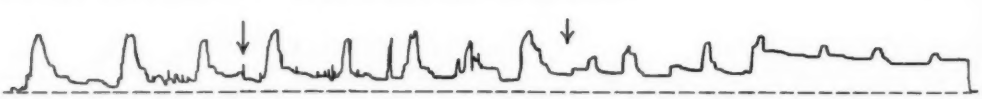

Fig. 5b. Same patient as in Figure 5a. Tracing 2,305. Observation of uterine motility made during first stage of labor, begun 3 hours and 58 minutes after ending of tracing in Figure 5a. At left-hand arrow 0.708 milligram of a-estradiol was administered intramuscularly. At right-hand arrow, 28 minutes and 30 seconds later, note increase in tone.

SUMMARY AND CONCLUSIONS

1. A-estradiol was administered intramuscularly to 42 women during the first stage of labor, simultaneously with the recording of their uterine activity with a Lóránd tocograph.

2. Seventeen patients registered a uterine reaction to the drug; 10 experienced a significant increase in uterine tone; 7 exhibited insignificant increases in the characteristics of their intermittent contractions.

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BRONCHOSCOPY IN TREATMENT OF POSTOPERATIVE ATELECTASIS

THE value of bronchoscopy in the diagnosis and treatment of pulmonary disease is widely recognized. Its value in the prevention and treatment of postoperative pulmonary complications is not so well known. Pulmonary complications following operation are a constant source of anxiety to the surgeon, and that such anxiety is warranted is emphasized in the studies of Scott and of Lemon. From statistics compiled from all parts of the world in which modern surgical methods prevail, these observers have estimated that some type of pulmonary complication develops in approximately 2 per cent of all operations and that one out of every 200 operations results fatally from this cause. Most observers are of the opinion that atelectasis is the most frequent type of pulmonary complication following operation, and that it is only when the atelectatic lung becomes secondarily infected that true bronchopneumonia occurs.

Many hypotheses have been advanced to explain the etiological factors involved in the production of postoperative atelectasis. The most widely accepted hypothesis is that postoperative atelectasis is produced by an obstruction of the bronchus by a plug of thick, tenacious mucus. Lee and Tucker, in 1925, were the first to demonstrate this bronchoscopically, and they showed furthermore that atelectasis could be relieved by removal of the obstructing mucous plug.

Atelectasis may occur as a complication following any operation, but it is more likely to occur in operations on the upper part of the abdomen and on the thorax than elsewhere in the body. This is to be anticipated because operations on the upper part of the abdomen and the thorax are prone to lead to the greatest interference with the normal respiratory movements and the effectiveness of the cough reflex. Atelectasis is estimated to occur in 10 per cent of cases in which operation is performed on the upper part of the abdomen and the thorax, in contrast to 4 per cent of cases in which the lower part of the abdomen is the site of operation. It occurs very rarely following operations on the extremities. Postoperative atelectasis is more likely to develop among patients suffering from bronchiectasis, infection of the upper part of the respiratory tract, or any other disability which leads to excessive accumulation of secretion in the mouth during the course of anesthesia than among normal, healthy persons. The length of time required to perform the operation, the type of premedication, the character of the anesthetic agent, and the ease of induction of anesthesia are also important etiological factors in the development of atelectasis. The

position of the patient during operation also has been demonstrated to be an important factor in the frequency with which postoperative atelectasis occurs. Gray found that he could reduce the incidence of postoperative complications approximately 30 per cent by simply placing the patient in the Trendelenburg position during and after operation.

If postoperative atelectasis occurs, it invariably develops within the first forty-eight hours after operation. In fact, evidence would seem to indicate that it is likely to occur before the patient recovers consciousness from the anesthesia. One would assume, therefore, that the factors involved in its development were present during the course of the operation. Postoperative atelectasis is not in itself a serious complication; its danger lies in the fact that it may be the precursor to the development of true bronchopneumonia.

Most patients, on recovering consciousness following operation, are able to expel the secretions retained in the tracheobronchial tree without a great deal of difficulty, and if atelectasis has occurred, it will subside promptly with expulsion of these retained secretions. This usually occurs within the first forty-eight hours after operation. Frequently, a patient who has atelectasis can be encouraged to expectorate any retained plug of mucus by support of the operative wound at the time of cough. If, however, the obstruction is allowed to remain in the bronchus and secondary pulmonary infection occurs, as it is likely to do, then atelectasis is but the precursor of pneumonia.

It is apparent, therefore, that in order to decrease the incidence of postoperative complications following operation, it is important to eliminate the factors that gave rise to their development. The most important preventive measure is the prompt removal of secretions in the tracheobronchial tree before, during, and immediately after, operation. This should be carried out while the patient is on the operating table, and a patient who has secretion in the airways should never be allowed to leave the operating room before the secretion has been thoroughly aspirated. Harrington has expressed the opinion that, in cases in which operation has been done on the thorax, and following any operation in which atelectasis is suspected, roentgenograms should be made while the patient is still on the operating table to be certain that a region of atelectasis may not be overlooked.

In many cases, the aspiration of retained secretion in the airways can be accomplished by the use of an aspirating catheter inserted through an intratracheal tube or directly into the larynx with a laryngoscope during and immediately after the operation. Frequently, however, the secretion may be beyond the reach of a catheter, or so viscid that it cannot be removed adequately by this method. In cases of this type, bronchoscopic aspiration of the tracheobronchial tree becomes essential to prevent the development of atelectasis. Bronchoscopy also is indicated in cases in which there is evidence of atelectasis which cannot be relieved by the more conservative measures. The procedure itself is relatively simple and can be performed without risk or undue discomfort to the patient. To be effective, however, bronchoscopic aspiration must be employed before secondary infection and pneumonia are superimposed on the primary atelectasis. The prompt aspiration of retained secretions from the tracheobronchial tree by catheter or bronchoscopy during and after operation until consciousness is recovered and the normal cough reflex is fully restored will reduce the occurrence of postoperative complications to a minimum.

In spite of the outstanding work of Lee and Tucker, who demonstrated that bronchoscopic

removal of retained secretion in the bronchus brought about a prompt disappearance of atelectasis, this method of treatment was slow in being accepted. Only within the past few years has it been employed more and more extensively in the prevention and treatment of postoperative atelectasis.

The problem presents itself as to the person best qualified to carry out bronchoscopic aspiration of the tracheobronchial tree during and following operation. The ideal situation would be for a trained and experienced bronchoscopist to be available for this procedure. This, however, is not always feasible. In certain instances the surgeon may have the training necessary to perform bronchoscopy, especially if he is interested in thoracic disease, but this is the exception rather than the rule.

It would appear that the trained anesthetist would be in an especially favorable position to take over this duty. It is the anesthetist who watches the patient most closely for evidence of aspirated secretion and vomitus during operation and immediately thereafter. With his training and skill in the introduction of intratracheal tubes, he should be especially adapted to learning the technique of bronchoscopy. Undoubtedly, in the not far distant future every qualified anesthetist will be required to have fundamental training in the field of bronchoscopy.

HERMAN J. MOERSCH.

THE "ALL OUT" ANESTHETIC AGENT FOR GENERAL ANESTHESIA IN ARMED FORCES AND CIVILIAN DEFENSE

THE position has been taken by teachers of anesthesiology that a routine agent and method of administration of anesthetics should be discouraged; that the anesthetic agent and the method should be suited to the case. This policy entirely overlooks two important factors upon which subsequent mortality and morbidity depend: (a) judgment required for selection—as in other fields this cannot be taught but is acquired through well balanced experience; and (b) the technical skill necessary to make the judgment effective—technical skill comes slowly, for some it is impossible; it is a physical qualification which many do not possess.

The anesthetic is administered to the patient in order that the surgeon may operate with safety and convenience and that the patient may have an uncomplicated recovery. Should these factors be jeopardized by the use of some new anesthetic, administered by a man who has spent but a few months learning a list of new anesthetic agents and techniques which he is to employ with what skill he can muster, under the conditions faced at the moment? Should casualties be looked upon as opportunities for the scientific education of the personnel administering the anesthetics or should the safe evacuation of the wounded, with the factors contributing to this end—the anesthetic, asepsis, and the intravenous therapy—be the surgeon's first and last concern in selecting the anesthetic to be used?

The alternative to the practice of using the many new agents and the new methods of inducing anesthesia now in vogue is a well considered routine which has been found to be safe and effective, is under control, and is accompanied by few regrets. The agent selected must be capable of fulfilling, to the degree indicated by the extent of operating necessary in a given case, the following basic surgical requirements, namely: controlling pain (dressings), producing unconsciousness, controlling superficial reflexes (débridement, foreign body removal, etc.) causing muscular relaxation (extremity work), controlling deep reflexes

(abdominal surgery), and finally permitting a reasonably rapid return to consciousness (reduced postoperative care).

The anesthetic agent must be capable of safe administration for the performance of surgery upon the extremities, the abdomen, the head and neck, and also of plastic surgery. It should be capable of intravenous administration in saline, glucose, plasma, or whole blood. It should be capable of use for painful dressings, for induction of general anesthesia, and to replace other agents. It should be capable of administration by improvised means and by simple portable apparatus. It should be easily available and should not be subject to explosion or to burning from unavoidable sources of ignition. It is obvious that cyclopropane, ethylene, ethyl chloride, chloroform, nitrous oxide gas and oxygen, the intravenous barbiturates—evipal, pentothal sodium—and avertin, also that regional block, caudal, or spinal anesthesia cannot meet these requirements.

A personal experience of more than thirty years with ether as an anesthetic agent has satisfied the author that the claims made for other agents and methods suggested as basic routines cannot be sustained. Numerous reasonable objections to the use of ether have become common knowledge, but it is most unfortunate that equally well known and accepted methods of meeting these objections have been generally ignored. Instead new agents are continually being introduced, but with accumulating morbidity and mortality percentages, the use of the newcomer is gradually eliminated and another aspirant promptly takes its place.

The objections to the use of ether are: difficulty of administration; lack of uniformity in purity, in manufacturer, in containers, and in preservation; flammability; tendency to cause dehydration and hemoconcentration; loss of liver glycogen; hyperglycemia due to anoxemia; loss of body heat; excessive salivation; tendency to postoperative pulmonary complications; postoperative nausea and vomiting.

Difficulty of administration is technical. Ether which is marked "for anesthesia" is now safe for use. Ether and air occasionally burn; explosions, however, are very rare. Intravenous therapy, now a matter of routine, eliminates dehydration, hemoconcentration, and glycogen loss. Anoxemia is no longer tolerated. Salivation is controlled by preoperative medication. Postoperative pulmonary complications always have been due to the aspiration of secretions and to anoxia. Postoperative nausea is caused in 90 per cent of cases by anoxia and in 10 per cent by the odor of ether.

With the casualty medicated for pain (morphine) and with the anesthesia induced by the intravenous administration of ether in saline, glucose or plasma; or by means of an improvised towel cone; a pharyngeal tube, a pocket flash light laryngoscope and an endotracheal tube—every type of war or civilian surgery can be carried out safely, effectively, and with minimum morbidity and mortality. The addition of a simple inhaler, nitrous oxide gas and oxygen, and a mechanical suction apparatus makes for luxuries which not only will render control easier but will likewise reduce the morbidity.

If such a basic routine is not only feasible but may be expected to meet the surgical requirements of all casualties encountered—the author has thus successfully anesthetized in civil practice patients with every condition referred to—then why not provide the technical skill required to carry out the practice? Intelligent hands are needed to do this job, directed by professional experience by men who have the whole picture in mind rather

than the promotion of some new anesthetic agent and method of administration.

The policy outlined does not make for glamor in the field of anesthesiology. The method is not spectacular. It will be viewed as retrogressive by those who place emphasis on equipment rather than upon ultimate broad scale results. Requisite technical skill is not easily acquired; it is a physical qualification which many men do not possess. Conversely, a perfect technical act may be performed with little knowledge of its implications.

On the other hand this policy may be depended upon to reduce the incidence of sudden death—the embarrassment of the expert who finds that his special apparatus or gases have not arrived or are out of commission—and, finally, to eliminate the unwise employment of agents and techniques not suited to the hazards faced in the operation at hand.

PALUEL J. FLAGG.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

AN excellent manual on oxygen therapy technique, *Manual of Oxygen Therapy Techniques*[1] by Albert H. Andrews, describes briefly but clearly the various accepted methods of oxygen administration, namely, tent, catheter, and mask together with the slight differences in technique required to use efficiently the different types made by the various manufacturers.

The author also summarizes the effectiveness of the various methods in a table headed "Factors Affecting Choice of Administrative Methods" which, as he states, reveals that no single method of administration can entirely replace either or both of the other methods.

The book should be available to all those concerned in the administration of oxygen therapy.

WALTER M. BOOTHBY.

THE excellent volume *Operating Room Technique*[2] is for nurses and will be of great value to students, graduate nurses, and operating room supervisors. The make-up of the book is well planned, the type is legible, the pages large for easy reference, and the paper of good quality. The book is profusely illustrated but it is unfortunate that more sequence photographs, such as the first three in Chapter X, are not used.

The first third of the volume is devoted to operating room fundamentals of which the chapters on personnel of the operating room, standardization of duties, and precautions are unusually good. The portion of Chapter VIII pertaining to absorption of catgut is not in agreement with the recent literature, nor is any mention made of cotton as a suture material. The chapter on sterilization should be more complete: for example, no mention is made of rinsing catheters after being sterilized in formaldehyde. Likewise, no illustration or description is given of sponges, laparotomy pads, laparotomy sheets, et cetera, as to size, how made and folded. The chapter on draping the patient is excellent. Unfortunately the photographs infer the nurses should drape the patient. The chapter and illustrations on surgical positions are excellent but the illustration of the positions might better precede each set of operations. A section with appropriate illustrations pertaining to hand signals for forceps, scissors, sutures, ligatures, knife and syringe would be of great aid. Also a paragraph on how to pass instruments, sutures, and ligatures should have been included.

The last two-thirds of this work is a procedure book in outline form with the layout in two columns, one column is a step by step procedure of the operation and the other column lists instruments and sutures used in each step. The technique of most operations is well illustrated; also the group illustrations of instruments used in various operations are excellent. The name of each instrument could better have been under the instrument rather than numbers, which require reference to a footnote. In the chapter on blood transfusions it is unfortunate that a word of caution is not given to use every safeguard to avoid giving incompatible blood.

A bibliography would be of great value in a book of this type. While every hospital should develop a procedure book of its own, this is a basically sound work for reference and a guide for the preparation of such individualized procedure books.

EARL O. LATIMER.

AN excellent view of the work of the Johns Hopkins Clinic is presented in *Gynecology; with a Section on Female Urology*[3] by Lawrence R. Wharton. The author emphasizes the fact that gynecology is no longer an exclusively surgical specialty but that the successful practitioner of gynecology must have an acquaintance with medicine, endocrinology, pelvic pathology, and chemotherapy. The first two chapters deal with regional anatomy, the next two with embryology and congenital malformations.

Section III, which embraces 13 chapters, discusses physiology and functional disturbances. These are well handled and the rational attitude of the author toward the question of endocrine therapy is to be commended. The discussion of these subjects is excellent and may be read with profit and interest by the experienced gynecologist as well as by the beginner.

The section devoted to uterine and vaginal prolapse presents these matters clearly and is in accord with the best gynecologic thought of today. The illustrations are clear and help materially in giving a clear understanding of the procedures which are described to one who may not have had a large operative experience. Only those procedures are included which are favored by the weight of gynecologic opinion. It is pleasing to find, under the heading of retrodisplacement, a reminder that wholly symptomless movable retrodisplacements may need no inter-

[1] MANUAL OF OXYGEN THERAPY TECHNIQUES; INCLUDING CARBON DIOXIDE, HELIUM, AND WATER VAPOR. By Albert H. Andrews, Jr., M.D., Chicago: The Year Book Publishers, Inc., 1943.

[2] OPERATING ROOM TECHNIQUE. By Edythe Louise Alexander, R.N. St. Louis: The C. V. Mosby Co., 1943.

[3] GYNECOLOGY; WITH A SECTION ON FEMALE UROLOGY. By Lawrence R. Wharton, Ph.B., M.D. Philadelphia: W. B. Saunders Co., 1943.

ference. The importance of shortening the utero-sacral ligaments, in operative management of retrodisplacement, is stressed.

The sections on inflammatory diseases, diseases of the vulva, and infections and tumors of the cervix are well done.

Among the readers of the section on hysterectomy there may be a difference of opinion concerning the advisability of cauterization of the cervix in cases in which subtotal hysterectomy is to be done immediately. The fastening of the broad and round ligament stumps to the stump of the cervix, thereby limiting the mobility of the ovaries and removing them from their normal location in the lateral fossae of the pelvis, will not meet the approval of all gynecologists.

There are excellent chapters on tubal disease, tumors of the ovaries, endometriosis, and sterility. The section on female urology adds a feature not usually found in texts devoted to gynecology. Coming from the Johns Hopkins Clinic, in which female urology has been so highly developed, it seems appropriate that this section should be included. An excellent review of the urologic field as applied to women is given and the material found here will be of use to many readers who wish a concise discussion of the urologic diseases in female patients together with suggestions as to the most efficient management. The Kelly method of cystoscopy is the only one illustrated. The author shares the preference of the clinic in which he works for this method.

The illustrations throughout are excellent. The reviewer, and this will be true of many of the older readers of the book, finds many old friends among the illustrations. A large number of the older drawings of Max Brödel, which had previously appeared in the works of Kelly and Cullen, are used. This is no criticism, for the illustrations of Brödel have never been surpassed, and there seems no good reason, when drawings as good as these are available, they should not be used. New illustrations by Miss Elizabeth Brödel and Leon Schlossberg, another of Brödel's pupils, are also very good.

The book is an excellent one. It seems rather better adapted to the practitioner, resident, or interne than to the undergraduate but will find a wide field of usefulness. One minor point may be mentioned. There appears a reference to Sir John Hunter. Although Hunter deserved any honor which might have been given him he never achieved knighthood or a baronetcy and remained plain John Hunter to the end of his days.

The publishers have done a workmanlike job and produced a book with sturdy binding, good paper, clear print, and excellent illustrations.

The book may be commended to those who desire a concise and accurate account of the present status of gynecology.

W. C. DANFORTH.

IN the work of the Argentine author, Lelio Zeno,[1] there are no minute descriptions of more or less well known operations, but there is an endeavor to lay down a number of principles to guide the surgeon with a fundamental knowledge of the subject of plastic surgery. There are several chapters on subjects of a general character which are, in our opinion, the most important of the book. These concern the study of surgical processes, such as wounds, burns, septic wounds, and scars, in which the plastic surgeon can intervene successfully in order to prevent malformations and morphological disturbances. The therapeutic ideas endorsed are based upon respect for the reparative forces already existing in the patient. Biological treatment stresses the importance of rest, complete immobilization of the affected parts in a functional position, drainage, and methods of improving the return circulation.

The chapter on burns is important because the principles of the biological treatment are laid down. Immobilization by direct plaster of paris covering of the burned surface is advised. Many examples illustrate the treatment advised which coincides in some respects with that recommended by those who are studying this problem at the present time.

The chapters on grafts—bone, skin, fat, aponeurotic—are based upon recent surgical experience as well as on the dicta of modern biology. The author's discussion is illustrated with operative sketches and descriptions of cases.

This work fills a definite gap in the medical literature of our South American republics.

HÉCTOR MARINO.

THE timely and profusely illustrated monograph, *Skin Grafting of Burns*,[2] deserves a place in the working library of every surgeon responsible for the care of patients with severe burns. One has only to study a few of the illustrations picturing the results obtained in cases of severe contracture or of cases of extensive burns with long delayed healing to realize that the authors "know whereof they speak" and have attained a degree of perfection in performance that represents the best in American surgery. Results such as they have depicted can be attained only by long and arduous devotion to the task of solving difficult surgical problems, the willingness to accept difficult cases after others have failed and the determination to bring them to a successful conclusion by patient perseverance and skillful specialized surgical care.

With war again bringing to the surgeon unprecedented numbers of patients with severe burns it is inevitable that men with little previous experience in the care of burns should be confronted with such cases in increasing numbers and should grope for new and better methods of treatment. The resulting confusion of ideas has been well set forth in the opening "Note to the Reader," in Chapter 3 on "Early Local Care," and in Chapter 16 on "Treatment of Burns in World War II." In the praiseworthy effort to evaluate the new methods that have been de-

[1] CIRUGIA PLASTICA. By Lelio Zeno. Buenos Aires: El Ateneo, 1943.

[2] SKIN GRAFTING OF BURNS; PRIMARY CARE, TREATMENT, REPAIR. By James Barrett Brown, M.D., and Frank McDowell, M.D., Philadelphia, London, and Montreal: J. B. Lippincott Co., 1943.

vised, particularly in Great Britain, and to give due credit to many different workers in this difficult field the authors have not emphasized quite as unequivocally as might have been done the importance of the first two of three simple surgical principles that form the basis of good treatment of the burned patient: prevent infection; prevent fluid loss; prevent long delayed healing and formation of contractures by replacing destroyed skin at the earliest possible moment. The importance of the third and last principle could hardly have been stressed more forcibly or illustrated more clearly.

The authors themselves have said:

"Bacteriological studies, strict asepsis, occlusive dressings, the application of pressure to wounds are all important considerations. In going over the finished book, it seems that even more stress should be placed on the foregoing elements, even though their importance might seem too obvious to require such stressing. Small essentials of washing hands between even slight contacts with each patient, of masking of all in attendance of open wounds, including the patients, and general ward cleanliness are almost natural procedures for any surgical service, but should have frequent attention called to them as fundamentals of success."

One cannot get away from the simple theorem that in spite of many divergences of opinion there must be *one best way* of caring for the burned patient, and that way will be found and agreed upon only when the fundamentals of "strict asepsis, occlusive dressings (to reduce to a minimum the danger of secondary infection) and the application of pressure" (to hold fluid loss to a minimum and to provide the most favorable circulatory conditions) are so clearly recognized that surgeons will stop looking for the magic application that controls infection and produces wound healing, and devote their energies toward preventing infection, preventing shock producing loss of fluid and providing the conditions that favor nature's constant effort to heal an open wound.

The dictum, "Get the areas as clean as possible, as soon as possible, and restore what full-thickness skin has been lost with free skin grafts," ignores the simple fact that the area should never have been allowed to become unclean.

A few pertinent and well expressed sentences deserve repetition:

"When a claim is made that a chemical will produce healing without scarring, the healing processes are apparently not understood" (p. 31).

The statement might be still more forceful if "without scarring" were omitted.

"The average donor area will be completely healed in about eight or nine days if it is not contaminated and is covered with fine-mesh grease gauze, though it may be desirable to protect it with a dressing for a few days longer. Such a donor area heals most quickly if the original dressing is left untouched through this period. The same would probably be true in burns of similar depth if one can be assured of their cleanliness. In either case if most of the derma is gone, infection may be devastating to the remaining deep epithelium and convert portions of it into full-thickness loss. An infected donor site usually requires about six weeks for healing and may have final patchy areas of scarring" (p. 35).

"Pressure dressings are a fundamental in the preparation of wounds for skin grafting. This continuous pressure probably does most to convert edematous, pinkish-gray, coarse granulations into firm, bright-red, fine ones. The pressure is applied by the external bandages which should be large and heavy enough for the purpose. Several varieties have been used including the commercial elastic, woven ones, muslin bandages, and 'Gauze rolls.' . . . Some medium is necessary to distribute the pressure evenly in crevices and prevent too much pressure on any bony prominences. Marine sponges were used for years for this purpose, but they have been replaced by ordinary cotton mechanic's waste which is more efficient, easier to use, and cheaper." (p. 48)

"The dressing should be regarded as part of the operation and probably has more to do with the 'take' of the grafts than any other step, except possibly the preparation of the wounds" (p. 78).

If one cannot have the opportunity of learning by direct observation of the work of these men and the "school" they represent there is no better substitute than careful reading and study of this excellent surgical treatise. SUMNER L. KOCH.

THE authors of *Changes in the Knee Joint at Various Ages*[1] have gathered specimens of knee joints from individuals of all ages; from the first to the ninth and tenth decades. These specimens have been obtained from necropsy material and amputations. Careful macroscopic and microscopic studies of these joints were made. From these studies it was noted that progressive stages of degenerative change take place in the joints as the individual becomes older.

These changes are carefully noted and charted. Excellent illustrations, both photographs and photomicrographs, demonstrate these changes. The book is thus an excellent addition to the literature on the pathology of arthritis. As a generally used medical textbook, it may not reach a wide circulation, but to those interested in the pathology of arthritis it should fill a great need. All who are interested in articular disease and the changes in joints should find it a most useful reference book.

R. K. GHORMLEY.

A VOLUME on *Orthopedic Subjects*[2] has been prepared and edited by the Subcommittee on Orthopedic Surgery of the Division of Medical Sciences of the National Research Council as one of a series of manuals for the military services. It is intended as a guide for medical officers who, without extensive training in this field, may find themselves responsible for the treatment of injuries to the extremities and spine. The book is divided into four sections dealing with the treatment of ununited fractures, injuries to the spinal column, compound fractures, and osteomyelitis.

An effort has been made throughout the work to have the subject matter concise and very practical. The principles involved are discussed but the theoretical aspects of the various subjects are subordinated to the detailed description of what to do and how to do it. The section on ununited fractures by Dr. Paul

[1] CHANGES IN THE KNEE JOINT AT VARIOUS AGES; WITH PARTICULAR REFERENCE TO THE NATURE AND DEVELOPMENT OF DEGENERATIVE JOINT DISEASE. By Granville A. Bennett, M.D., Hans Waine, M.D., and Walter Bauer, M.D. New York: The Commonwealth Fund, 1942.

[2] ORTHOPEDIC SUBJECTS. PREPARED AND EDITED BY THE SUBCOMMITTEE ON ORTHOPEDIC SURGERY OF THE COMMITTEE ON SURGERY OF THE DIVISION OF MEDICAL SCIENCES OF THE NATIONAL RESEARCH COUNCIL. Philadelphia and London: W. B. Saunders Co., 1942.

B. Magnuson is excellent. It points out clearly the importance of the necessary preparation of the patient for treatment, describes the types of operations that may be used and the advantages and disadvantages of each. A chapter is devoted to the special considerations of various regions and there are illustrations of anatomical approaches and diagrams of several operations.

Presumably patients with ununited fractures will be evacuated to large general hospitals, where surgeons experienced in this kind of work will be available. In any event, it is hoped that it will not be necessary for the surgeon who is to do a bone grafting operation with a motor saw to obtain his experience by practicing on a bone from the kitchen, as is suggested by Dr. Magnuson.

Dr. Arthur Davis draws upon his large experience in the treatment of fractures of the spine for a very detailed description of the management of fractures and dislocations in each region of the column. The descriptions of various techniques are quite clear and should be very helpful to those who have not dealt with many of these injuries.

The best section, in the opinion of the reviewer, is that on the treatment of compound fractures by J. Albert Key. The subject is thoroughly covered and the article gives the impression that it was written especially for the military surgeon with the various exigencies of this type of practice in mind. On the other hand, the part of the book which deals with osteomyelitis, also contributed by Key, has little bearing upon military surgery. It is devoted largely to a discussion of hematogenous osteomyelitis, a disease of childhood, uncommon in adults, and rare in military practice. It was written for a treatise on surgery and could well have been omitted from this manual, especially since the type of bone infection commonly arising from war wounds is dealt with in the sections on ununited and compound fractures.

Although the committee which prepared this book made no pretense of covering the entire subject of military orthopedics one wonders whether they might not have added to its usefulness by including chapters on the transportation of fracture cases and on amputations.

A. DeF. Smith.

THE little monograph by James entitled *Regional Analgesia for Intra-Abdominal Surgery*[1] outlines a technique of regional analgesia which the author claims should be widely applicable in abdominal surgery, particularly in the war wounded, when the use of general or spinal anesthesia may be contraindicated. His method consists of a bilateral intercostal block of the 6th to 12th thoracic nerves, supplemented by a posterior splanchnic block, and finally by infiltration of the line of incision. Adequate preliminary medication, gentle operative technique, careful psychological management, and supplementary use of oxygen or intravenous pentothal with inhalation of nitrous oxide-oxygen when indicated are emphasized in detail.

The unusual feature is the long duration of analgesia—three hours—and freedom from toxic effects with an agent known in this country as "pontocaine," hitherto reserved largely for spinal and topical anesthesia. The author is not specific as to the number of cases or the duration of his experience, but his favorable report justifies trial of pontocaine in a wider variety of regional nerve blocks. Since the method requires technical skill and is time consuming, it will probably not receive wide application in the gravely war wounded, where the need for minimization of shock justifies its trial.

Hugh O. Brown.

THE fundamentals of obstetrics are presented in logical fashion in Beck's *Obstetrical Practice*[2]. Beginning with the development of the ovary and the ovum and correlating this with the changes in the endometrium during the menstrual cycle, Beck points out the hormonal influences that bring about these physical changes.

The development of the fetus and its placenta and membranes is clearly described and adequately illustrated, and the physiological activity of the placenta is thoroughly explained. A discussion of the associated physiology of the fetus naturally follows.

The anatomical and physiological changes seen in pregnant women and studies of all of the systems and metabolism are covered adequately.

The diagnosis and management of pregnancy are clearly set forth. Outlines for physical examination and a dietary chart giving the nutritional value of various foods may be of considerable use and value to the general practitioner, especially to those doing deliveries at home or in hospitals in which dietary problems receive scant attention. The anatomy and dynamics of labor are well presented including the mechanism of labor in the various presentations and positions and in the first, second, and third stages of labor. The clinical course of labor and the management of the first, second, and third stages of labor are clearly set forth. Pelvimetry is reviewed and the importance of this aid to the diagnosis of potential complications is pointed out. The puerperium, postpartum care, and complications are well described, and lactation is well covered.

It is in the clinical subjects that this book best reflects the experience and wisdom of the author. Abortion and ectopic pregnancy are described by a writer obviously of large experience, keen observation, and a willingness to accept workable suggestions from others. The toxemias, early and late, are well described and the treatment outlined is simple, direct, and effective. An unusual amount of space is devoted to medical and surgical complications of pregnancy and the pathology of labor.

Pelvic deformities and their effect on labor are handled according to the older classification of de-

[1]Regional Analgesia for Intra-Abdominal Surgery; With Special Reference to Amethocaine Hydrochloride. By Norman R. James, L.R.C.P. & S. (Ed.), D.A. (R.C.P. & S. Eng.) London: J. & A. Churchill Ltd., 1943.

[2]Obstetrical Practice. By Alfred C. Beck, M.D. 3d ed. Baltimore: The Williams & Wilkins Co., 1942.

formed pelvis, although the Caldwell-Malloy classification is well reviewed.

Hemorrhages are discussed clearly, and conservative treatment in ablatio placentae is advocated. Cesarean section is given its proper place in the treatment of placenta previa, the operation of choice in the central type, in elderly primiparae, and in those in whom there is limited cervical dilatation.

The discussion of puerperal infection is thorough and the recommendations for treatment are sound.

The majority of obstetrical operations are well covered in the rather profusely illustrated section on operative obstetrics. Forceps, version, and cesarean section are fully covered, and a clear conception is given to the student regarding the contraindications and dangers as well as the advantages of the various procedures.

In general, this is a sound book, carefully worked out by an excellent practical clinician whose advice may well be followed by the great majority of practicing obstetricians. FREDERICK H. FALLS.

THE eighth edition of *The Principles and Practice of Obstetrics*,[1] a book that has been in use for 30 years, in itself, attests the quality of the book It is particularly fortunate that this valuable textbook is to be kept up-to-date and in daily use, and that Dr. Greenhill is the one to do it. His long association with Dr. DeLee is assurance that Dr. DeLee's teachings will be continued.

[1]THE PRINCIPLES AND PRACTICE OF OBSTETRICS. By Joseph B. DeLee, A.M., M.D., and J. P. Greenhill, B.S., M.D. 8th ed. Philadelphia and London: W. B. Saunders Co., 1943.

In the first place, the publishers have maintained their usual high standards in this book. The binding is attractive, the type clear, and the illustrations are cleanly reproduced. The only exceptions that we noted are a few photographs of operative procedures —notably the illustrations of the Waters technique of extraperitoneal cesarean section. In this instance, the original photographs were probably not clear—photographs of operations rarely are. This, however, is not a criticism of the publisher's work.

The arrangement of the book is essentially the same as in previous editions, and is clear. The index is detailed and adequate. The author has also provided a satisfactory bibliography at the end of each chapter for further reference and study.

The junior author has done an excellent piece of work in bringing this book up-to-date. This applies particularly to the sections that deal with physiology, embryology, endocrinology, and chemotherapy. Diagrams are used to present certain problems in a simple manner. The standard techniques of conducting normal labor, and the difficult problems that complicate labor and pregnancy are sensibly discussed. A little more space might have been devoted to the urologic complications of pregnancy and the puerperium, but that does not imply any neglect even of that subject. The chapters on puerperal infection, extrauterine pregnancy, abortion, uterine misplacements, and pelvic tumors in pregnancy are especially good. All in all, this is an excellent book, and Dr. Greenhill is to be commended for his service to the profession in keeping it up-to-date. LAWRENCE R. WHARTON.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

APPLIED ANATOMY OF THE HEAD AND NECK; FOR STUDENTS AND PRACTITIONERS OF DENTISTRY. By Harry H. Shapiro, D.M.D. Philadelphia, London and Montreal: J. B. Lippincott Co., 1943.

THE MECHANICS OF OBSTETRICS. By Norris W. Vaux, M.D., and Mario A. Castallo, A.B., M.D., F.A.C.S. Philadelphia: F. A. Davis Co., 1943.

KINETIC BANDAGING; INCLUDING SPLINTS AND PROTECTIVE DRESSINGS; THE KINETIC METHOD OF VISUAL TEACHING. By Seymour W. Meyer, B.S., M.S., M.D. Philadelphia: F. A. Davis Co., 1943.

RECONSTRUCTIVE SURGERY OF THE EYELIDS. By Wendell L. Hughes, M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1943.

BURMA SURGEON. By Gordon S. Seagrave, Lt. Col., M.C., U.S.A. New York: W. W. Norton & Co., Inc., 1943.

HYPERTENSION; A MANUAL FOR PATIENTS WITH HIGH BLOOD PRESSURE. By Irvine H. Page, A.B., M.D. Springfield, Ill.: Charles C. Thomas, 1943.

PHYSIOLOGY OF THE NERVOUS SYSTEM. By John Farquhar Fulton, M.A., D.Phil., D.Sc. (Oxon.), S.B., M.D. (Harv.). 2d ed. London, New York, and Toronto: Oxford University Press, 1943.

AMERICAN COLLEGE OF SURGEONS

HONORARY FELLOWSHIPS CONFERRED ON DISTINGUISHED RUSSIAN SURGEONS

HONORARY fellowships in the American College of Surgeons were conferred in Moscow on July 15 upon two distinguished Russian surgeons: Dr. Nicolai N. Burdenko, director of the Operative Surgery Institute, Moscow University, and Surgeon General of the Russian Army, and Dr. Sergei S. Yudin, surgeon in chief, Surgical Clinic of the Institute Sklifassovski, Central Emergency Hospital, Moscow, and director of the Surgical Clinic, Postgraduate Medical School.

The fellowships were conferred, under authorization of the Board of Regents, by Colonel Elliott C. Cutler and Lieutenant Colonel Loyal Davis of the Medical Corps, United States Army, during the recent official visit to Russia of the Anglo-American Surgical Mission. Among the other members of the mission were Surgeon Rear Admiral Gordon Gordon-Taylor; Major General D. C. Monro, professor of military surgery at the Royal Army Medical College, Millbank; Mr. E. Rock Carling; and Mr. R. Watson-Jones, all of England; and Dr. W. G. Penfield, professor of neurology and neurosurgery at McGill University, Montreal.

The purposes of the surgical mission were to study the results of war surgery and to explore the possibilities of extending medical relationships between the allied countries. Colonels Cutler and Davis reported a very unusual, valuable, and interesting experience. The fellowships were conferred during an impressive ceremony in the presence of the Commissar of Public Health and of the senior representatives of the Army, Navy, and other medical activities.

PRESENTATION OF CANDIDATES AND CONFERRING OF FELLOWSHIPS

"This gathering is momentous. We doctors now signify to the solidarity and common purpose of a majority of living peoples. The occasion justifies the hope that this junction of our races is but the beginning of a friendly and co-operative liaison for all time. As a token of this spiritual union Colonel Davis and I are empowered to grant honorary fellowships in the American College of Surgeons to two distinguished Russian surgeons, a function which heretofore has never occurred beyond the confines of our own country.

"By virtue of the authority vested, by the Board of Regents of the American College of Surgeons, in this Commission consisting of Colonel Cutler, professor of surgery, Harvard University, and Colonel Davis, professor of surgery, Northwestern University, we now declare that you, Nicolai Nilovic Burdenko, are hereby admitted to the honorary fellowship of the American College of Surgeons and may forever indulge in all the rights and privileges of that body of surgeons.

"By virtue of the authority vested, by the Board of Regents of the American College of Surgeons, in this Commission consisting of Colonel Cutler, professor of surgery, Harvard University, and Colonel Davis, professor of surgery, Northwestern University, we now declare that you, Sergei S. Yudin, are hereby admitted to the honorary fellowship of the American College of Surgeons and may forever indulge in all the rights and privileges of that body of surgeons.

"We congratulate ourselves that in this tumultuous world men of such eminence have found in service to the State a way of life that brings satisfaction to all."

For the Board of Regents of the American College of Surgeons.

ELLIOTT C. CUTLER

Professor of Surgery, Harvard University; Chief Consultant in Surgery, U. S. Army, European Theater of Operations.

LOYAL DAVIS

Professor of Surgery, Northwestern University; Senior Consultant in Neurological Surgery, U. S. Army, European Theater of Operations.

RESPONSE BY ACADEMICIAN BURDENKO

"I am deeply moved by the honor of electing me a member of the American College of Surgeons.

"I understand this honor as a generous approval of my papers and my work in the past and present. It makes me think about my work in the future; particularly now when the fight against fascists has reached a decisive stage.

"I recognize this election to be of deep and wide meaning.

"The last decade has shown that the United States is now the center of medical science and scientific problems are to be solved from the point of view of American science.

"During this year I have received very many proofs of attention from the United States. My contributions to world science and field surgery are but modest. It pleases me to share this great honor with all surgeons of my country."

RESPONSE OF PROFESSOR YUDIN

"You will easily understand my animation when immediately after one high honor the surgeons of a second great Allied country—U.S.A.—bestow on me another one.

"I know a little of your beautiful country. I am proud of my personal acquaintance—and even friendship—with George Crile, Howard Kelly, the late Mayo brothers and some other American surgeons of world fame.

"But could I dream 15 years ago that time would come when I should not only become an Honorary Fellow of the American College of Surgeons, but also should receive my degree and this diploma from the hands of the great Harvey Cushing's successor.

"By the way, it is an astonishing fact that the day of my decoration by the Allies completely coincides with the day I was severely wounded by a German shell on the eve of July 15, 1915.

"For the second time in the same quarter of a century our nations are united in their hard efforts to save their countries and the world's civilization. Now, just as it was for the first time, we are fighting with the same eternal dangerous enemy—Germany. But as it was on the first occasion, our British Allies are fighting again on our side.

"Victory will be ours. Nobody has any doubts about it, even our enemies. Let our scientific relations which have begun in time of such strained military needs, get stronger and flourish more and more after this victory and the won peace.

"In a time of struggle surgery is as necessary for victory as arms, transports and all kinds of supplies. But when the last gun of enemy will cease and the released humanity will turn with hope to the restoration of great destruction caused by the war, we surgeons will have to heal the wounds and injuries of hundreds of thousands of people who have won for us this victory.

"Your high election of me as Honorary Fellow of the American College of Surgeons will serve as a new additional stimulus for further development of my scientific work in surgery, which has already received from you such high estimation.

"I once more deeply and sincerely thank you."

Honorary fellowships in the Royal College of Surgeons of England were conferred by the British delegates just prior to the awarding of the honorary fellowships in the American College of Surgeons.

ADDRESS BY VICE-COMMISSAR KOLESNIKOFF

After the presentation of the fellowships, Vice-Commissar Kolesnikoff thanked the representatives of the two Colleges:

"Mr. Vice-President, Colonel Cutler, and all those present: The admission today of two outstanding Russian surgeons, Academician Burdenko and Professor Yudin, to the Honorary Fellowship of the Royal College of Surgeons of England presents itself to us, witnesses of this act, as an occasion of great cultural and political meaning.

"The Royal College of Surgeons of England since long ago has been famed as an organization, responsible in no small way for the development of surgery both in England and outside her boundaries. Amongst the fellows of this College have been, and are now, some of the oustanding representatives of English surgical thought. The greatest exponents of surgery of other countries have earned the honor of being honorary fellows of this College since its creation, in accordance with its established and glorious traditions. On every occasion the selection of honorary fellows amongst foreign scientists has been an unbiased and just appreciation of their really great technical contributions. Therefore, selection to an honorary fellowship of the Royal College of Surgeons of England, has always been a distinction in the eyes of the world's scholars. Similarly, the glory of the American College of Surgeons is well known.

"We are glad in the knowledge, that today the choice of the Royal College of Surgeons and the American College of Surgeons should have fallen on the two best represenattives of our native surgery. Both the new honorary fellows of the Colleges, Academician Burdenko and Professor Yudin, are deservedly famed in our country and outside her boundaries, as leading experts in the realm of their specialties. Not for nothing are they both worthy of highest scientific decoration of our country—the Stalin Prize; whilst Academician Burdenko with honor holds the title of Hero of Socialist Work.

"The outstanding contributions of Academician Burdenko in the development of neurosurgery,

his brilliant experimental work, his elaboration of the basic principles of a new type of field surgery, which has proved so brilliantly successful in the present war, make us certain that he will be a worthy member of the glorious family of the finest representatives of contemporary surgery that is combined in the Royal College of Surgeons and American College of Surgeons. Professor Yudin will bear the title of Fellow of the College with equal honor and worthiness. His name is tied with great successes in abdominal surgery, in plastic operations on the alimentary tract, in blood transfusion, and in the prophylaxis and treatment of infected wounds, etc.

"We, the representatives of the family of Soviet medical workers, are today justifiably proud of the great honor bestowed on Academician Burdenko and Professor Yudin. At the same time we express our sincerest appreciation to the Royal College of Surgeons of England and to the American College for this mark of distinction. In the name of the People's Commissar and in our name I ask you, Mr. Vice-President and Colonel Cutler to convey our thanks to your organizations. In the name of the People's Commissar and in our name I congratulate Academician Burdenko and Professor Yudin on their selection for the honorary fellowship of the Colleges.

"Today's occasion takes place in days of bitter warfare against the cruel enemy of Progressiveness—Hitler's Fascism! In this war, our medical teaching has extensively become the teaching of War Medicine, and it helps our armies in their struggle against this cruel foe. The admission of the most famous Soviet scientists to Honorary Fellowship of the Colleges marks in itself a strengthening of the scientific ties between the allied nations. I am certain those ties will strengthen further in the continuation of this struggle to complete victory over our common enemy."

CLINICAL CONGRESS NOT TO CONVENE IN 1943

THE annual Clinical Congress of the American College of Surgeons will not convene in 1943.

Motivated primarily by patriotism, in arriving at their decision the Regents were influenced by the present conditions surrounding the general war program which have led to a greater burden on the members of the surgical profession in their local communities as a result of the large proportion of the profession which is serving with the armed forces. The Regents by this action took cognizance of the desire of the profession to do nothing which would interfere with the successful prosecution of the war program such as would be caused by temporary absence of its members from civilian duties during the Congress, embarrassment of the transportation system, and interference with the work of a local profession in preparations and presentations incident to such a meeting.

At the annual meeting of the Board of Regents which will be held later in the year, fellowship in the College will be conferred *in absentia* on the class of initiates of 1943, as there will be no convocation exercises. At the same time the list of hospitals, cancer clinics, medical services in industry, hospitals conducting programs of graduate training in surgery, and medical motion pictures, that meet the College standards, will be approved and later published.

All present officers, Regents, Governors, and standing committees will continue in office during the ensuing year.

The International Society of Surgery (now confined to the Western Hemisphere) which was to have met in special session during the 1943 Clinical Congress, under the presidency of Professor José Arce, of Buenos Aires, has also cancelled its meeting.

A TRIBUTE TO THE DOCTORS OF NORTH AMERICA

THE American College of Surgeons has received through the Division of Cultural Relations of the United States Department of State a photostatic copy of a parchment presented to the American Ambassador in Brazil by the Brazilian Medical Associations of Rio de Janeiro on the occasion of Independence Day in the United States, which, as translated, reads as follows:

INDEPENDENCE DAY

The Medical Associations of Rio de Janeiro, through their Presidents, send to the grand statesman, Franklin D. Roosevelt, on this date, and through the medium of the worthy Ambassador Caffery, manifestations of fellowship which their Brazilian colleagues, inspired by the best sentiments of Pan-Americanism, send in tribute to the North American doctors.

Academia Nacional de Medicina, Prof. Dr. Joaquim Moreira, da Fonseca.
Academia Brasileira de Medicina Militar, Coronel Dr. Florencio de Abreu.
Colegio Brasileiro de Cirurgiões, Dr. Oscar Alves.
Sindicato dos Medicos do Rio de Janeiro, Dr. Alvaro Tavares de Souza.
Sociedade dos Ex-Internos dos Hospitais Militares, Prof. Dr. Estellita Lins.
Sociedade Brasileira de Dermatologia e Sifilografia, Prof. Dr. Joaquim Motta.
Sociedade Brasileira de Gastroenterologia e Nutricão, Prof. Dr. Augusto Brandão Filho.
Sociedade de Ginecologia e Obstetricia do Brasil, Dr. Jorge Sant' Anna.
Sociedade Brasileira de Oftalmologia, Dr. Ruy Rolm.
Sociedade Brasileira de Pediatria, Dr. Cesar Pernetta.
Sociedade Brasileira de Tuberculose, Dr. Alberto Renzo.
Sociedade Brasileira de Urologia, Prof. Dr. Alvaro Cumplido de Sant' Anna.
Rio de Janeiro, July 4, 1943.

RESPONSE BY THE BOARD OF REGENTS

The following response on behalf of the Board of Regents of the American College of Surgeons is being transmitted to the Medical Associations of Rio de Janeiro through official governmental channels:

"The officers and members, of the Board of Regents of the American College of Surgeons extend their grateful thanks to the Medical Associations of Rio de Janeiro for the expressions of solidarity which they have extended to their colleagues in the United States through the medium of the United States Ambassador to Brazil. It is the earnest desire of the Regents that their friends in Rio de Janeiro should appreciate that this same spirit of brotherhood is felt no less keenly in the United States.

"There is every assurance that the alliance which has been formed between Brazil and the allied nations will more speedily and certainly bring about the victory for right and for justice."